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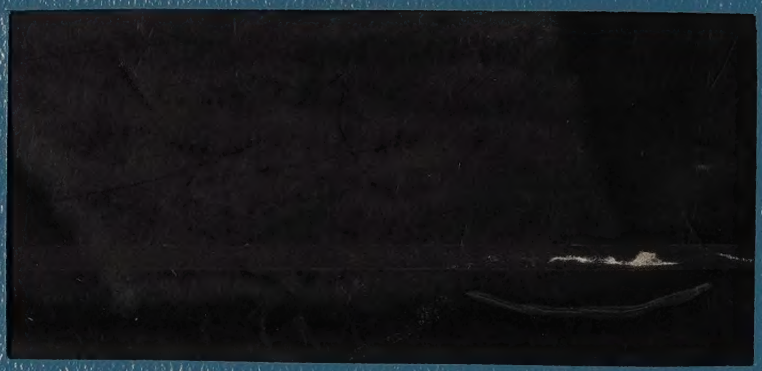

INSTRUCTION AND MAINTENANCE MANUAL

DYNATRAC® LOCK-IN AMPLIFIER

MODEL 397EO

MAY, 1984

ITHACO, INC.
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MANUAL CHANGES

ITHACO MODEL 397EO LOCK-IN AMPLIFIER

Date June 23, 1983
May 11, 1984

Supplement A
B

Make all changes in this manual according to the Errata below. Also check the following table for your instrument serial number and make the listed changes in your manual.

MODEL	SERIAL NO	MAKE MANUAL CHANGES	MODEL	SERIAL NO	MAKE MANUAL CHANGES
397EO	all with Options	1, 2			
397EO	65975 up	3			
397EO	65974 down	4			

1. MODEL 397EO Option 06 - PROGRAMMABLE GAIN - ADDENDUM

The Programmable Gain Option has been modified to permit easier read out of gain status when the 397EO is operated under manual control. Rev. F provides a low impedance output instead of the 47K output described in 3.12.2. This has been accomplished by the addition of U4 and U5. U4 (7403) is an open collector output circuit. When the front panel control is in "R", U4 is disabled. Performance is as described in 3.12.1.

When the sensitivity switch is in any other mode U4 is activated. The external interface must supply pull-up resistors if it is desired to use this mode.

When used with the ITHACO Model 385EO both functions are implemented. When the sensitivity switch is in the "R" position gain is commanded. In other positions gain status in read automatically.

2. OPTION 10 X and Y OUTPUT

The standard Model 397EO has a single, phase insensitive output. When using an external integrator for smoothing, errors result due to the squaring function required to compute outputs. For optimum use of the Model 385EO/ 386EO it is desirable to have outputs of both phase sensitive detectors available.

These outputs are scaled for 10 volt FS and made available by Option 10.

3. See Section 4.9 Digital Voltmeter
All references to Option 05, BCD Output were removed and added to Appendix A.

4. Operating Instructions, Troubleshooting, Replaceable Parts, Assembly and Schematic Drawings for Option 05, BCD Output are included in Appendix A.

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ITHACO

DYNATRAC® 397EO
lock-in amplifier

- *THE FIRST LOCK-IN DESIGNED SPECIFICALLY FOR ELECTRO OPTICAL MEASUREMENTS AND APPLICATIONS*
- GPIB *INTERFACE AVAILABLE*

DIGITAL and ANALOG METERS
BUILT-IN VOLTAGE and CURRENT PREAMPLIFIERS
CONTINUOUS GAIN CONTROL
PROGRAMMABLE (OPTION)
NOISE MEASUREMENT (OPTION)
A and B OUTPUT (OPTION)
FRONT and REAR INPUT/OUTPUT CONNECTORS
UNIQUE ZERO SUPPRESS - increase display accuracy by 10

IPS 132

The DYNATRAC ® 397EO Lock–In Amplifier is a general purpose lock–in with new features that are particularly useful in the Electro–Optics research and process control fields.

These unique 397EO features are standard:

- Analog and digital meters for ease of setup and increased measurement accuracy.
- Built in voltage and current preamplifiers. Designed for use with long cables.
- Continuous gain control for convenient output scaling.
- Output reads in % of full scale.
- Unique zero suppress controls that enable the user to expand any 10% increment to cover the full 0–10 volt output range while maintaining calibration.
- BNC inputs/outputs on front and rear panels.
- Dimmer control for digital meter.

Optional 397EO features include:

- Noise Measurement
- Programmable gain
- Ratio Measurement
- Remote Preamplifiers
- External Coupler

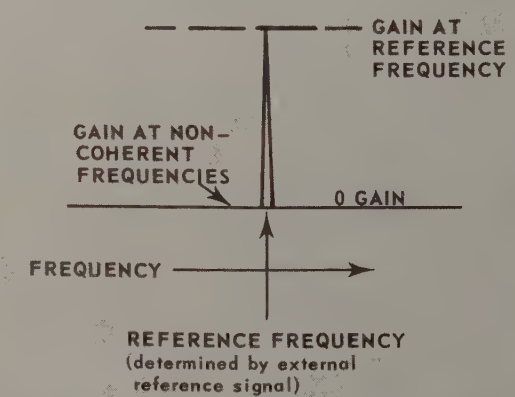
You also get these standard DYNATRAC features that are not available in other lock–ins except as extra cost options.

- Interference rejection performance and accuracy are maintained under all operating conditions.
- The vector amplitude output eliminates phase controls and phase drift errors.
- A tracking filter near the input always eliminates harmonically related interference and automatically suppresses large transients, unlike lock–ins from competitors, where one must set a filter, set a different mode, or buy an extra cost option.
- You can measure a signal that is not precisely coherent, if this signal is close enough to the reference frequency to be within the bandwidth of the output (time constant) filter.

WHAT DOES A LOCK-IN AMPLIFIER DO?

A lock–in amplifier is, in essence, a narrowband filter followed by a rectifier. The center frequency is controlled by an external reference signal, and the output is a dc level proportional to the amplitude of an input signal that is coherent with this external reference. A plot of gain vs frequency of a lock–in amplifier should look like the figure at the right. There is only a single frequency where an output can occur, and that frequency is controlled by the reference signal. For example, a reference signal might come from a light beam chopper, or from an oscillator that also modulates the signal source. "Super filter" would be a better description for a lock–in, because extremely narrow bandwidths can be achieved without the drift problems of conventional tuned filters. Interferring signals hundreds and even thousands of times larger than the signal to be measured can be routinely discriminated against.

IDEAL LOCK–IN AMPLIFIER FREQUENCY RESPONSE



SPECIFICATIONS (all specifications worst case unless otherwise noted)

SENSITIVITY: Continuously variable: 1μV to 1V for 10V (100%) output; 10pa to 1ma for 10V (100%) output.

SENSITIVITY CONTROLS: 6 decade switch: 10μV to 1V; 100pa to 10μa, or 10na to 1ma, as determined by input mode switch. **Remote** position disables sensitivity and expand controls and enables the external programming option. **Expand ×10 control** instantaneously increases output level by 10. **Continuous gain control:** 10 turn locking control with greater than 10:1 range.

INPUT: Voltage mode: True differential with one side of input amplifier connected to ground through a 68Ω resistor, and also to the isolated shell of the input BNC connector. This eliminates ground loops by providing good common mode rejection over the entire operating frequency range.

INPUT IMPEDANCE: Voltage mode: >15MΩ//<100pf **Current mode:** Virtual ground

MAXIMUM SOURCE CAPACITANCE IN CURRENT MODE: I Mode –up to 1000pF (cable + source capacitance) for additional 1% error at 10 kHz. **100 I Mode** – up to 30,000pf (cable + source capacitance). Capacitance may be higher, but could affect frequency response at high frequencies.

MAXIMUM INPUT WITHOUT DAMAGE: Voltage mode: 200 VDC **Current mode:** 5V

TRANSIENT REJECTION: The effect on the output will not exceed 1% of full scale under the following conditions: transient amplitude 10,000 × full scale, transient width 50μsec, normal mode, sensitivity 10μV, time constant 2.5 sec.

SINUSOIDAL INTERFERENCE REJECTION: The output level will not change more than 1% of reading at an output level of 1V in the presence of a sinusoidal interferring signal that is at least 2500 times the signal level that produces this 1V output. The attenuation of this interferring signal will be at least 250,000. Conditions: signal and reference frequency 100 Hz, interferring frequency 70 Hz, expand ×10 mode, 100μV sensitivity, 8 sec time constant.

HARMONIC AND SUBHARMONIC REJECTION: >55 dB

FREQUENCY RANGE: 10Hz to 10kHz – all specifications apply; 6Hz to 14kHz – typical useful range (see Fig. 1)

MINIMUM DETECTABLE SIGNAL: (no external preamp) .5pa, 20nV typical

SELF NOISE: <.5% of full scale rms at 25 sec TC, maximum sensitivity, expand ×10, (**voltage mode** – shorted input, **current mode** – open input). See Figure 2.

OUTPUT LEVEL: 10V for full scale (100%) output

MAXIMUM OUTPUT SCALE FACTOR: 1V/100nV, 1V/pa

OUTPUT ACCURACY: **Recorder output** accuracy 2% of reading, 1V to 10V output. **Analog meter** accuracy ±3% of full scale. **Digital meter** – 3½ digit meter with 0.1% ±1 count accuracy.

OUTPUT: **Drift:** Less than 0.01%/°C (1mV/°C) normal; less than 0.1%/°C (10mV/°C) expanded. **Offset:** <5mV in normal mode (25°C). **Impedance:** 1kΩ±1%. **Linearity:** Better than .1%.

OUTPUT TIME CONSTANT: 2.5msec to 25sec, true 12 dB/octave at all settings, ±2% accuracy.

ZERO SUPPRESS RANGE: >10× full scale (expand mode). **Step switch** calibrated to .1%. Steps are 0%, 10%, ...100%. In **expand mode,** steps are multiplied by 10. See pages 4 and 5 for an example of how this feature can be used to accurately suppress the first digit without loss of calibration when you are measuring small changes in large signals. **Continuous control** fills in between steps. **On/Off** switch turns continuous control off.

REFERENCE: **Input Level:** >150mV from average value of reference waveform. **Input Impedance:** 10MΩ//90pf.

ACQUISITION TIME: Worst case 30 seconds. This results when the reference is switched from 10 Hz to 10 kHz (or the reverse). Under normal circumstances, acquisition is faster.

OPERATING TEMPERATURE RANGE: +5°C to 45°C

MECHANICAL: Size: 17" x 3½" x 18½" (43.2 x 8.9 x 47 cm) **Weight:** 16 lbs. (7.2 kg)

CONNECTORS: Signal Input: (front and rear) BNC. **Recorder Output:** (front and rear) BNC. **Reference input:**(front and rear) BNC. **Programming option:** 24 pin Micro Ribbon*. **Remote Preamp Power:** 3 pin XLR

POWER LINE CONSTRAINTS: 47–440 Hz, 90–130 volts AC or 180–260 volts AC selectable on rear panel.

POWER: 40 watts

OPTIONS & ACCESSORIES (see pg 6 & 7): Remote Preamplifiers, Noise, Programmable Gain, Ratio, A & B Output.

*Registered trademark of Amphenol

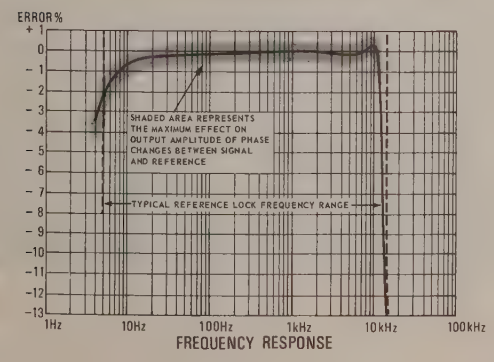
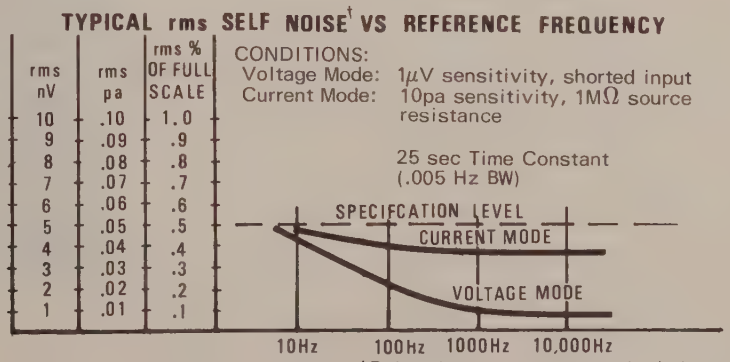


Figure 1

TYPICAL rms SELF NOISE† VS REFERENCE FREQUENCY



†Referred to input; for p–p multiply by 5

Figure 2

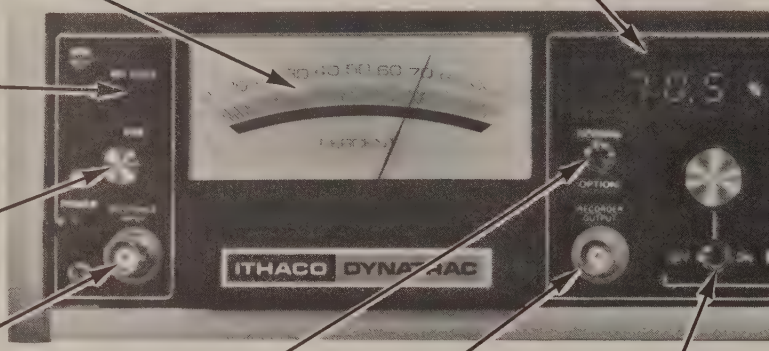
FRONT PANEL

Analog Meter indicates percent of full scale. First digit can be suppressed by the zero suppress switch without loss of calibration giving meter reading resolution of substantially better than 1 percent.

3½ Digit Digital Panel Meter makes set up easier and increases measurement accuracy. In expand mode, the most significant digit can be suppressed to give meter resolution of 4½ digits.

No–Lock Light indicates that the instrument is not locked to the reference signal, or that the reference signal is absent.

Dim Control varies digital meter brightness.



Reference Input (also on rear panel). The frequency range over which all specifications apply is 10 Hz to 10 kHz. Typical useful range is 6 Hz to 14 kHz. See Figure 1.

Recorder Output (also on rear panel) gives 10 volts with full scale input signal.

Normal/Option switch enables user to display on the meters and at the output connector the normal output or the option output. Settings need not be changed when the expand switch is used.

Continuous **Zero Suppress** with On/Off switc provides, in conjunction with the step zero sup press switch and the expand switch, a continuou offset range of greater than 10× full scale.

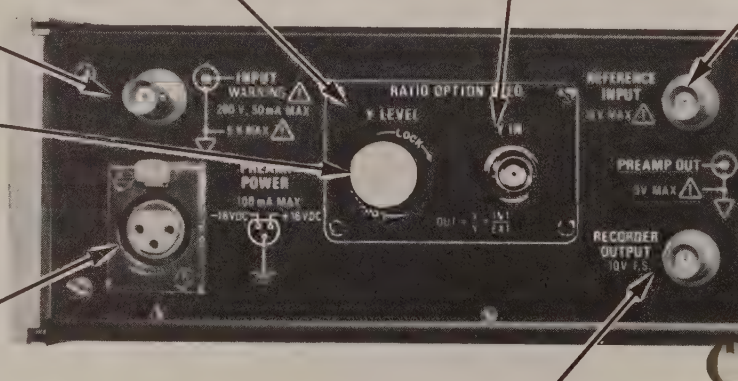
REAR PANEL WITH RATIO OPTION

Signal Input (also on front panel)

Noise Option 01 or Ratio Option 02 or A and B Option 10

Denominator (Y) Input

Adjust level of **Denominator (Y Input).** Must be a positive dc signal, and will normally come from the output of a second identical lock–in.



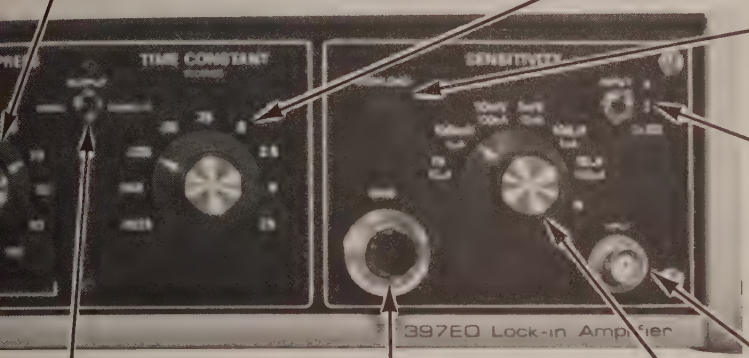
Power Connector for Optional Preamp

Recorder Output (also on front panel)

Precision step **Zero Suppress** enables user to expand any 10% output increment without loss of calibration. For example, with a reading of 87.6%, set zero suppress switch to 80%, set expand switch to ×10, then read 76.X on the meters and at the output connector. (7.6X volts output)

Output Filter has true 12 dB per octave roll-off at all settings. This provides optimum selectivity regardless of time constant setting.

Overload Light monitors overload at *all* points in the instrument except the DVM. Distortion at the overload point will not exceed 2 percent.



Select built–in **Voltage or Current Preamp.** In the current mode, the input can be connected directly to photo diodes or photo tubes without load resistors and with several feet of cable.

t ×10 Expand switch provides additional gain of 10 at the t. Zero Suppress need not be after expanding.

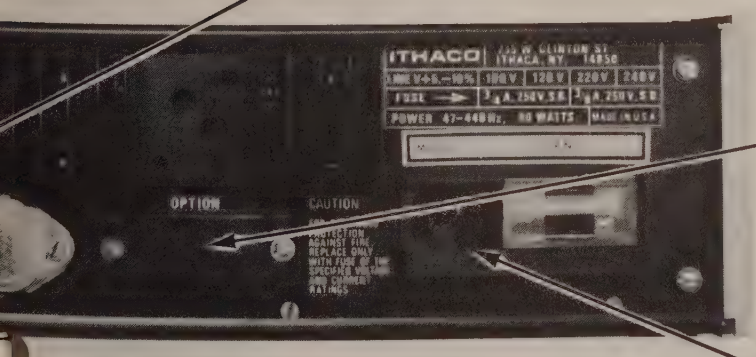
True differential **Input** (also on rear panel) with one input connected to the shell of BNC. The BNC is isolated from the front panel and grounded through a 68Ω resistor to eliminate ground loops.

Continuous Gain Control enables user to scale output to any desired level. For example, set output to proper level using a known standard sample. Or set output to 100% using standard and measure % deviation from the standard. The Digital Meter is linear to > 130%.

Sensitivity 1μV to 1V, and 10 pa to 1 ma for full scale output, including the effect of the output ×10 expand switch. At max sensitivity the output scale factor is 1V per 100nV or 1V per pa. Optional remote preamplifiers provide even greater sensitivity.

nce Input
on front panel)

Current Preamp Output
for dual beam work



Programmable Gain Option I/O Port

Power Connector

OPTIONS AND ACCESSORIES

NOISE OPTION 01

The Analog Noise Option, located on the rear panel, provides for measurement of narrow–band noise. The bandwidth is selectable from 50 Hz to 0.5 Hz in a 5–1.56–0.5 sequence using the front panel Time Constant switch (2.5msec for 50 Hz, 8msec for 15.625 Hz, etc.). The center frequency ranges from 10 Hz to 10 kHz as determined by the reference input to which the instrument is locked.

The noise measurement is not affected by the presence of a coherent signal, which means that signal and noise can be measured simultaneously and independently.

RATIO OPTION 02

This option is electrically identical to that used in other DYNATRAC 390 Series Lock–Ins. The numerator is supplied by the lock–in, while the denominator is supplied at the rear panel by external source. The ratio may be performed either before or after the zero suppress; this selection being made by moving a connector inside the lock–in. As shipped, the ratio occurs prior to the zero suppress.

SPECIFICATIONS

Accuracy (25°C ±5°C): Ext. input 0.1 to 10VDC ±2%

Input Impedance: (0< Vin<12 VDC) 300KΩ minimum
2MΩ typical

Input Voltage (X or Y): 12V maximum

(Ratio adjustable to unity for $0.5\ X \leq Y \leq 2X$)

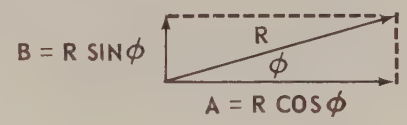
PROGRAMMABLE GAIN OPTION 06

This option allows the user to control the gain of the lock–in externally and can be used in conjunction with a Model 385EO/386EO to both control and read the results from the lock–in. When the sensitivity switch is in the "R" position, this option replaces the functions of the sensitivity switch and the expand switch.

In addition, this option provides four outputs. These indicate when the sensitivity switch is in the remote position, when the lock–in is overloaded, when it is out of lock, and when the power is on. Both inputs and outputs are compatible with standard TTL logic, and utilize a total of ten lines.

A AND B OUTPUT OPTION 10

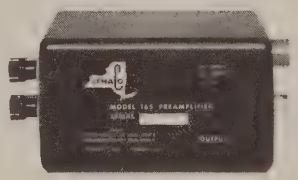
The standard 397EO has a single phase insensitive output R derived by analog vector summation of 2 identical channels, A and B. These channels are the Time Constant filtered outputs of 2 phase sensitive detectors (PSD) operated in quadrature. When using the 385EO or 386EO to collect data for a host computer, much better results are obtained if the Coupler operates directly on two quadrature channels rather than on the normal 397EO vector sum output. Option 10 makes internal channels A and B available externally, scaled for 10V full scale.



Option 10 is necessary for correct digital measurement of noise using the 385/386. It is also needed for correct computation of signal vector sum R when the noise is on the same order of magnitude as the signal, or greater. (See ITHACO IPB 0121)

PREAMPLIFIERS (See IPS 112)

MODEL 164
AC Current Input Preamp



MODEL 165
HiZ/LoZ

MODEL 168
Differential

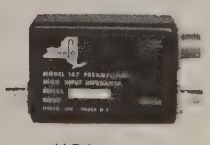
SPECIFICATIONS

MODEL	164			165 TRANSFORMER	165 DIRECT	166	167	168
INPUT	Current Preamp, Single–Ended			Differential	Single–Ended	Single–Ended	Single–Ended	Differential
GAIN	10^8 V/A	10^6 V/A	10^4 V/A	60 dB (×1000)	20 dB (×10)	40 dB (×100) ±.2 dB	20 dB (×10) ±.5 dB	20 dB (×10) ±.1 dB
TYPICAL INPUT Z (1 kHz)	Virtual Ground			10kΩ	100MΩ//25pF	40kΩ//25pF	100MΩ//25pF	100MΩ// 25pF each side
RECM SOURCE IMPEDANCE	>1MΩ	>100kΩ	>10kΩ	< 1kΩ	< 10MΩ	< 5kΩ	< 10MΩ	< 10MΩ
BANDWIDTH	dc–1 kHz	dc–6 kHz	dc–60 kHz	1Hz–1 kHz **	0.1Hz–600 kHz	0.1 Hz–210 kHz	0.1 Hz–600 kHz	.02 Hz–600 kHz
OUTPUT VOLTS	20V pk–pk			20V pk–pk	20V pk–pk	8V pk–pk	20V pk–pk	10V pk–pk
OUTPUT OFFSET (Typical)	Adjustment Provided			< 50mV	< 50mV	AC Coupled	< 50mV	< 3mV
OUTPUT Z	50Ω			50Ω	50Ω	50Ω	50Ω	50Ω
COMMON MODE REJECTION	———			80 dB min	———	———	———	105 dB @ 50–500 Hz 65 dB @ 50 kHz
NOISE	* 3 × 10^{-14} A	* 5 × 10^{-13} A	* 2 × 10^{-11} A	———	5nV/$\sqrt{Hz}$	1nV/$\sqrt{Hz}$	5nV/$\sqrt{Hz}$	7nV/$\sqrt{Hz}$
POWER	±13V to ±18V, 10ma			±13V to ±18V, 25ma	±13V to ±18V, 25ma	–13V to –25V, 25ma	±13V to ±18V, 25ma	±13V to ±18V, 25ma
WEIGHT (Nominal)	110 grams			810 grams		115 grams	110 grams	460 grams

* 1 Hz Bandwidth, at 1 kHz
** $R_s = 1\Omega$

391V1M7 Cable Assembly required with remote preamplifiers

MODEL 166
Medium Z



MODEL 167
HiZ

ACCESSORIES (CONTINUED)

MODEL 385EO/386EO DUAL CHANNEL INTEGRATOR/COUPLER

Model 385EO/386EO Dual Channel Integrator/Coupler interfaces the analog output of a lock–in amplifier (LIA) or other instrumentation to a host computer. Its use greatly enhances the performance of *existing* equipment with respect to speed, accuracy, and convenience of operation. It processes D.C. input voltages from two independent channels, A and B.

- Couples any Two Phase Lock–In Amplifier to the GPIB (IEEE 488 Instrumentation Bus) or to an RS–232 Serial Port.
- Couples a Model 397EO *AND* provides gain control
- Integrating A/D converters smooth very noisy inputs and have short settling time
- Dual integrators on each channel. Allows for correct measurement of average D.C. value even when the instantaneous amplitude flickers above and below ground level.
- Variable length of integration period allows optimization of speed–accuracy tradeoffs. (20ms to 200sec)
- Input sensitivity from ±10mV full scale to ±10 volt full scale
- AUTO–GAIN® automatic range switching within the 385EO/386EO preamplifier
- 385EO version provides GPIB communications with host
- 386EO version provides for RS–232 communications
- Digital baseline correction for offset nulling or zero suppression, both channels independently
- On board processor (6809 with 2K RAM) unburdens host computer, allowing operation with simple bench top controllers such as the HP–85™.
- Computes the following outputs:
  - A
  - B
  - $R = \sqrt{A^2 + B^2}$ (Vector Sum)
  - Q = Arctan (A/B) (Phase Angle)
  - A+B (Sum)
  - A–B (Difference)
  - A/B (Ratio)

$$\bar{A} = 1/N \sum_{1}^{N} A_i \text{ (mean of N measurements, ch. A)}$$

$$\bar{B} = 1/N \sum_{1}^{N} B_i \text{ (mean of N measurements, ch. B)}$$

$$Sa = \sqrt{\sum_{1}^{N} (A_i - \bar{A})^2 / N} \quad \text{(noise, Ch. A)}$$

$$Sb = \sqrt{\sum_{1}^{N} (B_i - \bar{B})^2 / N} \quad \text{(noise, Ch. B)}$$

- Benefits for Lock–In Amplifier operation:
  - Eliminates most gain changing at the LIA due to wide dynamic range of 385EO/386EO. Results in high absolute accuracy.
  - No troublesome time–constant switching transients
  - Programmable autoranging delay to suppress spurious AUTO–GAIN switching on transients
  - Remote gain setting of ITHACO Model 397EO Lock–In Amplifier
  - Faster and more accurate than analog ratio and noise options

The Model 397EO for optimum flexibility, must be fitted with Option 10. This option provides quadrature outputs A and B which connect to the A and B inputs of the 385EO/386EO. The 397EO phase output information, while skewed relative to the reference, provides admirably for phase–independent determination of amplitude via the 385EO/386EO. The combination of the 397EO and the 385EO/386EO results in a truly superb electro–optical measuring system.

In some applications the normal output may be used in conjunction with another input, such as source level, to provide a ratio.

To take advantage of the remote gain capability of the coupler/397EO combination, the 397EO must have the Remote Gain Option (Option 06) installed. A Model 385V2 cable is required.

ACCESSORIES (CONTINUED)

PROGRAMMABLE PREAMPLIFIER

The ITHACO 1201 Gain–Programmable Preamplifier is designed for use in computer controlled and manual applications requiring state of the art performance. In addition to full gain control, the amplifier gain status, remote operation status, overload status, and high pass/low pass filter status are available as inputs to the control device.

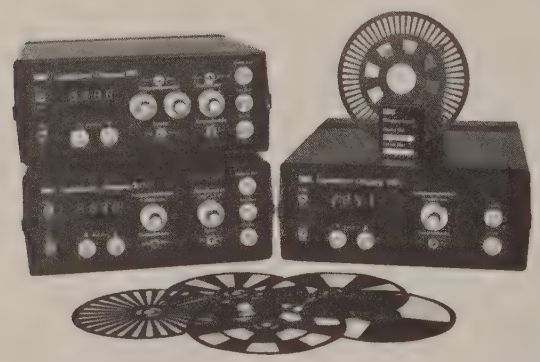
This high performance amplifier is an excellent choice for a wide variety of application areas from evoked potential measurements to Infrared Radiometry. (See IPS 134 and IPS 136).

CURRENT AMPLIFIER

The ITHACO 1211 Current Preamplifier is designed to meet the critical needs of research and test applications in the 10^{-2} to 10^{-11} ampere range. Featuring high speed (to 10μsec rise time) and low noise (less than 5X 10^{-13} amperes) with gain accuracy better than ±3% and drift less than 0.005%/°C or day, the 1211 truly delivers performance not found in any competing instrument.

The 1211 is essential to demanding applications such as measurement of low level photo current and Deep Level Transient Spectroscopy. (See IPS 137)

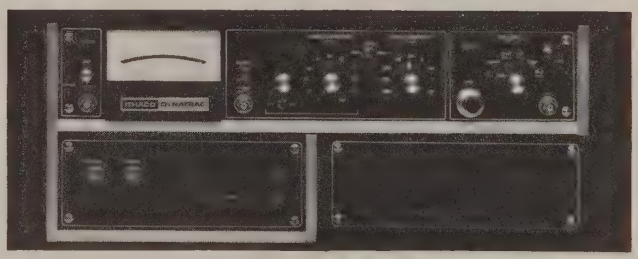
220 SERIES VARIABLE SPEED LIGHT CHOPPERS



The 220 Series represents a significant advance in optical chopper technology. A high speed and low speed Drive Motor unit and 8 interchangeable blades cover a frequency range from 0.1 Hz to 6 kHz. The basic 220 Controller unit yields ultra-low phase jitter. Chopper blades are precisely photoetched from spring steel stock. 221 provides phase-locked "electrical shaft" operation of 2 heads to synchronize and phase adjust chopping at separate points in the beam paths. 222 allows precise linear sweeping of the chopping frequency. The Series is designed for a wide range of low-level, electro-optical applications with lock-in amplifiers, photon counters and other signal processing instrumentation. See IPS 145 and IAN 37.

INSTALLATION ACCESSORIES

ITHACO has available several mounting options for lock–in amplifiers and accessories. These include the SRM–18 and SRM–24 Slide Rack Mounts for mounting lock–ins in 18" or 24–30" cabinets and RM–1 and RM–2 Rack Mount kits for mounting one or two 385EO/386EO Couplers. The Model 3900RM–18 or 3900RM–24 kits consist of either 18" or 24" slides and a blank panel and mounting hardware for a 397/385 system. The Model 3900 Bench Top Case mounts a 397 and 385 to form a free standing system (Model 3970 Lock–In Amplifier–– see IPS 146).



Model 3970 Lock–In Amplifier (Benchtop Version)

SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE. COPIES OF ITHACO'S 12 MONTH WARRANTY AVAILABLE UPON REQUEST.

ITHACO

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PHONE 607–272–7640 TWX 510–255–9307

PRINTED IN USA

SECTION 2

INSTALLATION

2.1 INSPECTION

2.1.1 GENERAL

Before shipment, this unit was found to be free of electrical and mechanical defects. As soon as the instrument is unpacked, inspect for any damage that may have occurred in transit. Save all packing materials until the inspection is complete. If damaged in any way, a claim should be filed with the carrier and a copy forwarded to ITHACO. ITHACO will then advise you as to the disposition of the equipment and will arrange for repair or replacement without waiting for a settlement of a claim against the carrier.

2.1.2 VISUAL INSPECTION

A visual check should be made to confirm that there are no broken knobs or connectors, and that the case and panel surfaces are free of dents and scratches.

2.1.3 ELECTRICAL INSPECTION

The instrument should be checked against its electrical specifications (see Section 4).

2.2 INSTALLATION

For bench top use, the only installation that is required for the DYNATRAC® Model 397EO Lock-In Amplifier is to connect it to a power source (see paragraph 2.3, Power and Grounding).

For those installations where rack mounting is desired, a RM-1 Rack Mounting Kit is provided. The RM-1 is easy to install. Simply remove the four screws from the side panels near the front, install the rack mounting brackets and replace the screws.

2.3 POWER AND GROUNDING

Unless otherwise specified, all units are shipped with a six foot, three conductor power cord equipped with a grounded plug. Normally, the 397EO should be connected to a grounded power source. See paragraph 3.8 for a detailed description of ground connections.

CAUTION: Before connecting the 397EO to the line, check that the line voltage selector (inside rear panel power input filter) is in the proper position. The setting may be read through the rear panel windows in the power input module.

50 - 400 Hz Setting	Voltage Range	Recommended Slo-Blow Fuse
100	90-110 VAC	3/4A
120	105-130 VAC	3/4A
220	195-240 VAC	3/8A
240	210-260 VAC	3/8A

To change the power setting, first turn off the unit. Remove the power cord and slide the plastic window aside. Flip the "fuse pull" lever out and remove the fuse. The small printed circuit board in the power input filter provides the power switching connections. Remove the board by hooking a stiff wire into the hole at the rear of the board and pulling straight out. Orient the board so that the desired setting will be visible through the window when the board is reinserted. Reinsert the board in the desired orientation. Flip the "fuse pull" lever back and install the recommended fuse. Slide the window back and reconnect the power cord.

SECTION 3A

PRINCIPLE OF OPERATION

3.1 INTRODUCTION

The Model 397EO is an auto phasing lock-in amplifier designed specifically for electro optical measurements and applications. Functionally the 397EO is equivalent to a tracking backpass filter with an adjustable bandwidth (time constant) and gain followed by an envelope detector with a calibrated zero suppress. The calibrated zero suppress is a new feature that, with its accurate expansion (x10 gain) of the detected output, increases resolution of the output.

Lock-in amplifiers are used to detect weak signals of known frequency and phase. Almost all lock-in amplifiers rely upon the known frequency and phase to perform a synchronous detection operation to eliminate asynchronous (ramdon phasing) signals and achieve narrow bandwidths. Figure 3.1 is a block diagram of a basic lock-in system which one might devise and which illustrates the lock-in technique.

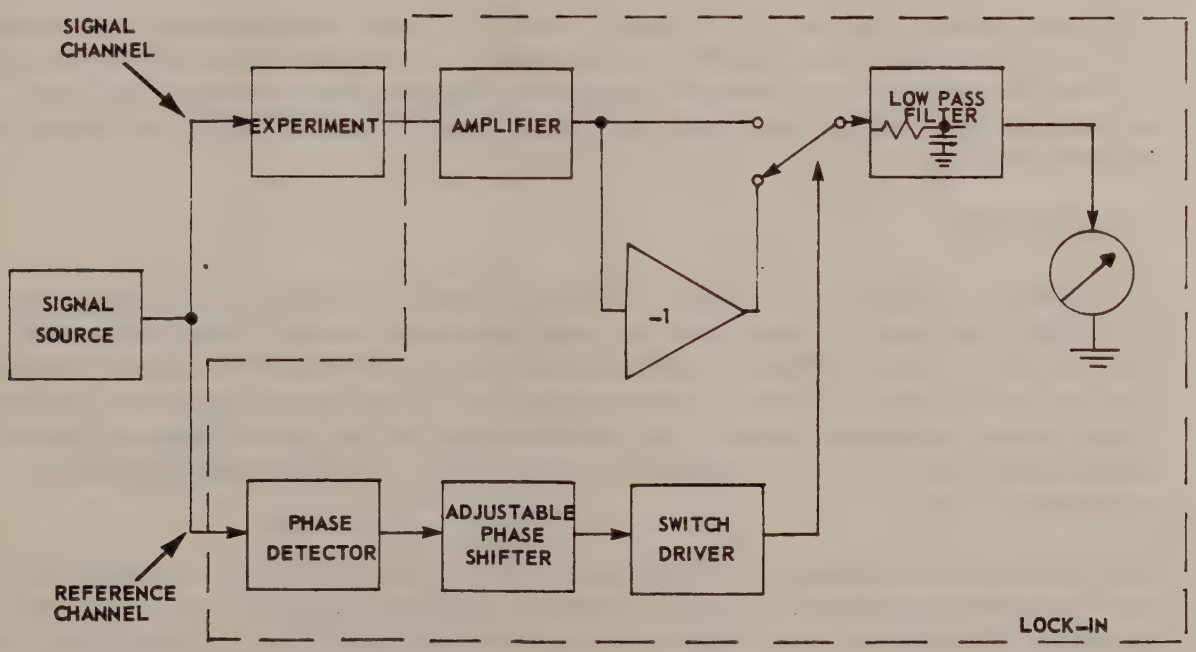


FIGURE 3.1 BASIC SYSTEM

In the basic system, as in almost all lock-in systems, the signal source is monitored in order to synchronize the switching of the reversing switch. A manually adjustable phase shift allows the reference channel phase shift to be adjusted in order to toggle the switch at the optimum time for proper detection. The low-pass filter time constant is selected according to noise and settling time requirements.

If one examines Figure 3.1, one will soon realize that the basic lock-in system will respond not only to the fundamental frequency of the signal source, but to all odd harmonics as well. Thus some sort of bandpass filter must be installed before the synchronous detector (reversing switch) in order to strip off the unwanted harmonics.

Several lock-in amplifiers have been marketed which are not much more complicated than that in Figure 3.1 with a predetection filter. The filter is manually set for each operating frequency. A variety of low-pass filter time constants is also available.

3.2 DYNATRAC® LOCK-IN AMPLIFIERS

A lock-in which uses manual filter settings as described above, has the disadvantage of being cumbersome to use. The settings must be adjusted each time the operating frequency is changed. The ITHACO DYNATRAC Lock-In Amplifiers eliminate the cumbersome manual filter setting by using the old technique of heterodyning.

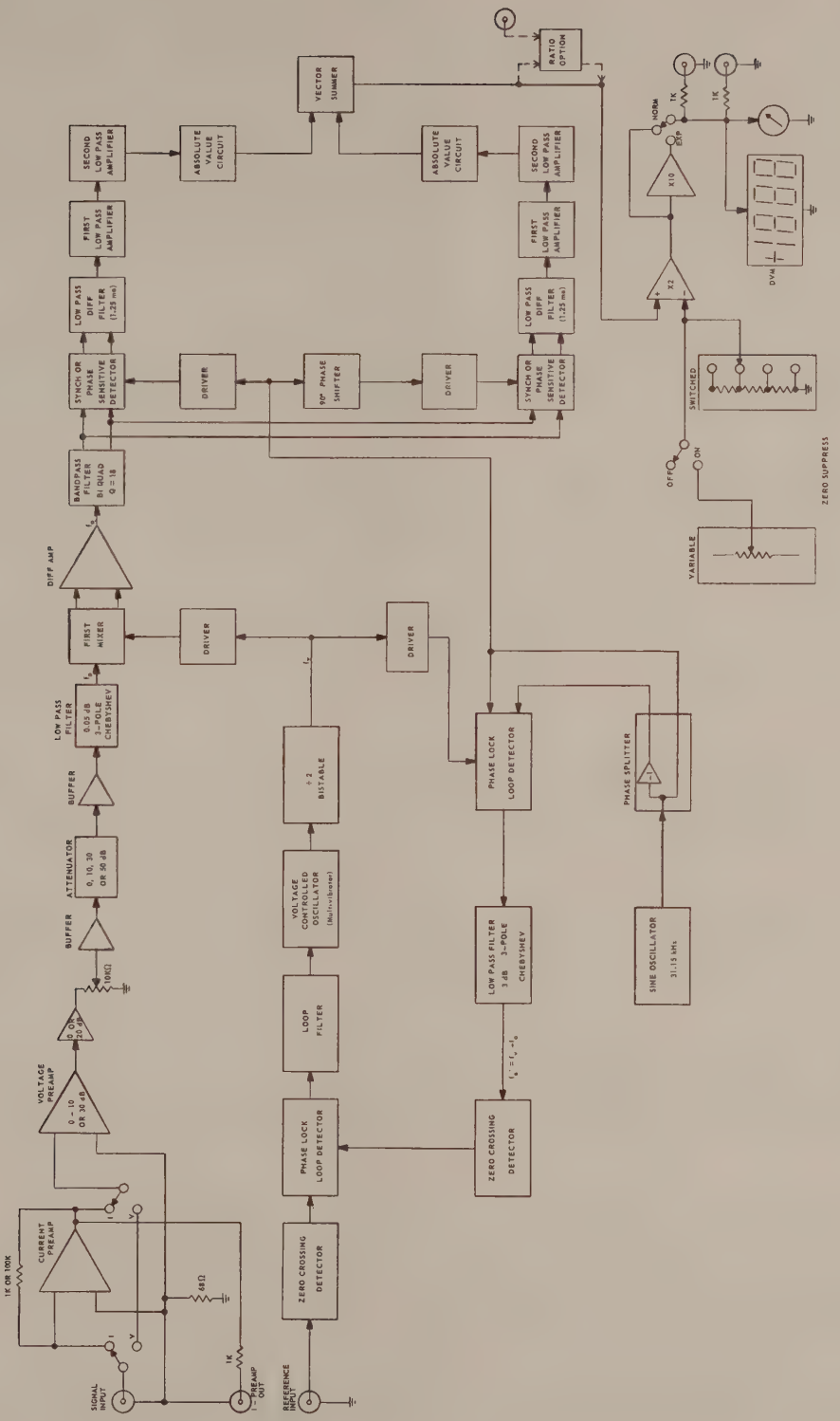
The input signals in both the reference and the signal channels are heterodyned to a fixed i.f. frequency before reaching the synchronous detector. This process allows the predetection filters to be preset at the factory. Experimental frequency changes within the operating range of the Model 397EO often require no adjustment at all.

3.3 MODEL 397EO

The 397EO is designed to measure the amplitudes of signals which are at (or very near) the same frequency as the reference input signal. The instrument is very simple to use in that no filters need to be switched, and no phase controls need to be adjusted. In fact, none are provided. One needs simply to supply a signal and a reference, switch the time constant to the desired smoothing and adjust the sensitivity to the desired level. Figure 3.2 is a block diagram of the Model 397EO.

The signal to be measured is connected to one of the input BNC connectors. A switch permits selecting voltage or current input modes. Note that the signal input connector shields and the preamp output connector shield are isolated from the signal ground by 68 ohms. This effectively reduces susceptibility to ground loops. All other BNC connector shields are grounded directly.

The signal enters the input BNC, either on the front or rear panel, from there goes to the input mode switch. This switch directs the signal to either the



ITHACO DWG C32280, 9/78

FIGURE 3.2
397EO
BLOCK DIAGRAM

voltage or current preamps and also determines a current gain of 10^3 or 10^5 V/A in current mode. The voltage preamp receives the signal from either the input BNC or the current preamp output. The voltage preamp has a gain of either 0, 10, or 30 dB which is selected by the sensitivity switch. Following the voltage preamp is a second voltage amplifier with a gain of 0 or 20 dB which is also switched by the sensitivity switch. Then the signal goes through the variable attenuator, a potentiometer on the front panel, and through a buffer to the stepped attenuator. This attenuator has four steps of attenuation. They are 0, 10, 30 and 50 dB.

The sensitivity switch also shows a "R" in the fully clockwise position. This position is used for the Programmable Gain Option 06. In the "R" position without this option the input to the low pass amplifier is grounded and the 397EO in turn does not pass a signal.

The attenuator output is buffered and fed to a 3-pole, 0.05 dB ripple Chebyshev Low Pass Filter. The filter provides some bandwidth restriction of the input signal to reduce overload sensitivity to large high frequency signals.

The first mixer is driven by the frequency "f_V" which is equal to $f_O + f_S'$. f_S' is the frequency applied to the reference input (usually the same as the signal frequency f_S). f_O is the i.e. frequency of the instrument (nominally 31.15 kHz).

The output of the first mixer and the diff amp consist of signals at the frequencies $(2N+1)\ (f_V) \pm f_S'$ where $0 \leq N < \infty$ and N is an integer. Thus the lowest frequency out of the diff amp is at f_O, the i.f. frequency. The bandpass filter, centered at f_O, strips off the higher frequencies.

Two phases (180° apart) from the bandpass filter go to the phase sensitive detectors. The signals in the phase sensitive detectors are rectified in the same manner as in the basis system, Figure 3.1.

The phase sensitive detector outputs are first filtered by a fixed 1.25ms low pass filter. The first and second low pass amplifiers provide additional filtering. By switching their time constants, the 397EO time constant may be selected from .0025s to 25s in a 2.5-8.3-25 sequence.

The Model 397EO contains two separate phase sensitive detectors. The two detectors are switched in quadrature (notice the 90° phase shifter) which makes the outputs of the two low pass amplifiers proportional to $\cos\phi$ in one case and $\sin\phi$ in the other. ϕ is the phase angle between the signal and the drive.

The vector summer accepts the absolute values of the low pass output signals and generates an output equal to the amplitude of the signals from the low pass amplifiers.

The vector summer drives the zero suppress summing amplifier and this in turn drives the expand X10 amplifier. The zero suppress switch located on the front panel, is fed from the reference voltage on the DVM Card, which makes the

switched zero suppress accurate enough to cancel the most significant digit of this output. Then the expand amplifier is able to move the next most significant digit to the most significant position increasing the resolution of the analog and digital meter by a factor of 10.

The 397EO is equipped with two output meters, an analog and a digital, both of which are connected to the recorder output BNC. The digital meter can be connected to the BCD option 05 to give a BCD equivalent of the output.

3.4 NOISE BANDWIDTH AND SIGNAL-TO-NOISE RATIO

The output signal-to-noise ratio of the 397EO can be shown to approach that of a regular lock-in with the same time constant when measuring an AC signal under the presence of random noise. The convenience of the 397EO does therefore not sacrifice the performance.

The noise bandwidth for the various time constant settings can be found in Table 3.2 (section 3.9.2). These are the values which are approached for normal signal-to-noise ratios. For very low signal-to-noise ratios, the effective noise bandwidth will be larger.

3.5 GENERAL

The Model 397EO will measure the amplitude of a signal which is locked in frequency to the reference signal. It is capable of extremely narrow bandwidths (-3 dB at .00409 Hz minimum up to 37.8 Hz maximum). It may also be used in an unlocked mode provided that the signal and reference frequencies be separated by less than the bandwidth of the instrument.

3.6 FREQUENCY RANGE

The DYNATRAC 397EO covers the frequency range 10 Hz to 10 kHz with rated accuracy. The instrument is usable from approximately 6 Hz to 14 kHz. A special automatic "boost" circuit facilitates rapid acquisition to any frequency between 10 Hz and 10 kHz in less than 30 seconds.

3.7 REFERENCE MODES

3.7.1 REFERENCE SIGNAL CHARACTERISTICS

In operation, the experiment must supply a suitable reference signal to the Model 397EO. The reference signal can be any signal which crosses its mean twice per cycle, i.e. a sinewave, square wave, triangle wave, etc. The reference signal must exceed +40mV above its mean each cycle.

The reference input includes 1 second and 0.5 second high pass filters in series with a 0.22 microsecond low pass filter. The phase of the reference signal is determined by the negative going zero (i.e. near) crossing. The reference is therefore independent of the reference amplitude provided that the threshold level (+40mV) of the reference input comparator is exceeded.

3.7.2 NO LOCK LIGHT

The NO LOCK LIGHT on the front panel indicates when the 397EO reference circuit is out of lock due to a missing or improper reference signal. The NO LOCK light will turn off completely only when the internal reference signal is at the same frequency as the reference input signal. Since phase accuracy is not required in the 397EO, the NO LOCK light will not light if there is a small phase error between the reference input signal and the internal reference signal. Such phase errors can occur, for instance, in swept frequency experiments. The NO LOCK light will dim and then blink noticeably before acquisition finally occurs.

3.7.3 SWEPT FREQUENCY OPERATION

The 397EO may be used with a swept reference frequency provided that the maximum sweep rate is not exceeded. Table 3.1 gives the maximum sweep rate and the time to sweep over a 10 kHz frequency range. At the sweep rates shown, the amplitude error will be less than 5%.

Time Constant Setting (Seconds)	Slew Rate Hz/s	Time To Sweep 10 kHz
25	2×10^{-5}	5×10^{8} sec
8	2×10^{-4}	5×10^{7}
2.5	2×10^{-3}	5×10^{6}
.8	0.02	5×10^{5}
.25	0.2	5×10^{4}
.08	2	5000
.025	10	1000
.008	10	1000
.0025	10	1000

TABLE 3.1 SWEEP SPEED VS BANDWIDTH

3.7.4 ASYNCHRONOUS OPERATION

The 397EO may also be used with reference and input signals that are not locked in frequency. The Model 397EO will measure the amplitude of the signal input provided that the difference between the signal and reference frequencies is less than half the bandwidth. To measure with less than 0.5 dB error, choose a bandwidth at least 6.5 times the difference frequency. Table 3.2 lists the .5 dB and 3 dB half bandwidths.

3.7.5 MEASUREMENT ACCURACY

Due to the design of the vector summing circuit (see 4.3.1), the 397EO output voltage will vary ± .24% as the phase of the signal is varied. This will show up for example during a swept measurement as a "ripple" on the output voltage. An example is shown on Figure 3.3 where the 397EO is swept from 500 Hz to 15 kHz with the same 1V rms signal fed to signal and reference inputs. The vertical scale is expanded by using the zero suppress, increasing the recorder sensitivity.

3.8 INPUT AND GROUND CONNECTIONS

The signal to be measured must be connected to either the front or rear panel input connectors. The impedance of the input of the 397EO is greater than 15M ohm in parallel with 100 pF. The low self noise of the 397EO input stage combined with the high input impedance guarantees excellent performance over a wide range of source impedances.

The 397EO has a true differential input amplifier with one input connected to the floating ground. The floating ground which appears on the ring of the input BNC's, is then tied to chassis ground through a 68 ohm resistor. This ground isolation helps eliminate the effects of ground loops on the signal input.

If higher sensitivity or higher CMRR is desired, the ITHACO Model 168 Differential Amplifier is recommended.

3.8.1 INPUT LEVELS

⚠ CAUTION: The Inputs to the 397EO are partially protected against abuse. However, damage to the instrument may result if the following limits are exceeded:

Signal Input

Voltage Mode - The signal input (center conductor) is coupled through a 200V capacitor and will permit application up to 200 VDC without damage. The AC signal at this point must be kept below 30 volts peak-to-peak to prevent damage.

The floating ground (input BNC shells) is connected through a resistor to chassis ground. To limit dissipation in this resistor to a safe level, no more than 5 volts should be applied to the shells.

In Current Mode, the input is DC coupled, and the applied voltage must be limited to 5 volts with respect to floating ground. An input current of 50mA will cause less than 5 volts to appear at the input.

Reference Input

Like the signal input, the reference input is coupled with a 200V capacitor. To avoid damage, DC inputs must be kept below 200 volts while AC inputs must be kept below 100 volts peak-to-peak.

⚠ WARNING - On the signal and reference inputs, the front and rear connectors are connected in parallel. As a result, any voltage applied at the rear will be present at the front and vise versa. Thus if a high voltage is applied, a potential shock hazard can result. In these cases, insulating caps should be attached to unused input BNC's.

The user should also note that the floating ground is present at both the signal input and preamp output BNC's. Thus a voltage applied to any of these grounds will be present on the others.

Time Constant Settings	0.5 dB Half Bandwidth	3 dB Half Bandwidth	Noise Bandwidth
25s	0.00155 Hz	0.00409 Hz	.005 Hz
8s	0.00465 Hz	0.0123 Hz	.015 Hz
2.5s	0.0155 Hz	0.0409 Hz	.05 Hz
.8s	0.0465 Hz	0.123 Hz	0.15 Hz
.25s	0.155 Hz	0.409 Hz	0.5 Hz
.08s	0.465 Hz	1.23 Hz	1.5 Hz
.025s	1.55 Hz	4.09 Hz	5.0 Hz
.008s	4.62 Hz	12.2 Hz	14.7 Hz
.0025s	14.5 Hz	37.8 Hz	44.3 Hz

TABLE 3.2 HALF BANDWIDTHS

3.9 INDICATORS AND CONTROLS

3.9.1 SENSITIVITY AND GAIN

The sensitivity control is located on the right hand portion of the front panel. The control adjusts the gain of the "front end" of the instrument in decade steps from 10 μvolts full scale to 1 volt full scale. For each setting, a sinewave input at the rms level shown, will provide 10 volts d.c. at the output connector and a full scale deflection of the front panel meter. This sensitivity can be increased to 1μV or 10pa through use of the output EXPAND switch.

The gain control permits continuous adjustment of sensitivity. Calibration of the sensitivity switch is valid when the gain control is fully advanced.

3.9.2 TIME CONSTANT

The time constant switch adjusts the time constant of the low-pass amplifier stages and thus the bandwidth of the instrument. The root mean square deviation of an amplitude measurement may be determined by using the value of Table 3.2 as noise bandwidth. Also see Table 3.2 for the 0.5 dB and 3 dB bandwidth.

3.9.3 ZERO SUPPRESS

The 397EO is equipped with three controls and one indicator of zero suppression. The main control is a stepped switch calibrated in 10% increments of full scale (100%). The others are a vernier which covers the range of 0 to 15%, a switch to turn it on or off and a yellow indicator light.

The stepped control is used to suppress the most significant digit so that the output will be in the range of 0 to 10V when the output expand

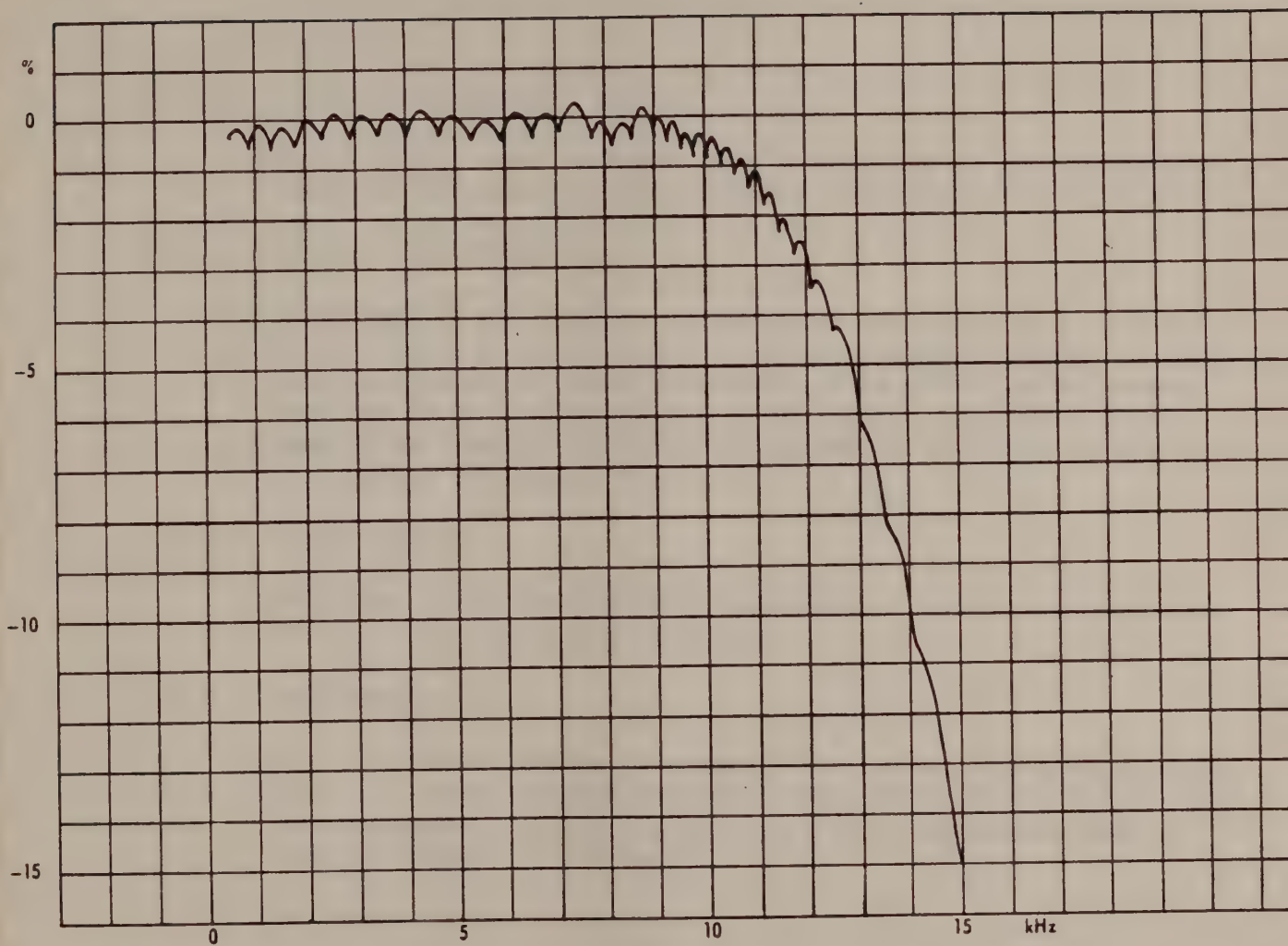


FIGURE 3.3 397EO ACCURACY PLOTTED WITH 0° PHASE DIFFERENCE BETWEEN SIGNAL AND REFERENCE

switch is on. This control has a two fold application. It is capable of suppressing the DC output of the 397EO so that the smaller changes in the signal can be viewed or recorded. It is also calibrated so that the absolute values can also be measured.

The variable control is used to cover everything between the steps of the switched zero suppress. This control can be turned on or off by the switch below it. Both zero suppress switches turn on a caution indicator light. This tells the user if either of the zero suppress controls are in use and whether the meters and the output are indicating the true value.

3.9.4 INPUT MODE SWITCH

This switch is used to select the gain of the current preamplifier and to bypass the current preamplifier when using the voltage input mode.

3.9.5 OUTPUT EXPAND SWITCH

This control is used to select a DC output gain of either X1 or X10. It can be used in conjunction with the zero suppress switch or alone just to increase the overall sensitivity of the 397EO. In the expand mode the dynamic range of the front end is also increased because there is one tenth of the signal voltage present in the front end to give full scale on the output.

3.9.6 POWER SWITCH

The Power switch controls the primary power input to the unit. The LED above the switch is a pilot light.

3.9.7 OVERLOAD LIGHT

The overload detector circuits consist of a number of window detectors located at strategic points throughout the 397EO circuits. The overload light indicates that a signal, somewhere within the instrument, is outside of one of the windows.

The causes of overload are:

1. SENSITIVITY set too high.
2. TIME CONSTANT set too low causing peaks of the ripple to overload the output amplifiers.
3. OVERLOAD by a non-synchronous signal somewhere in the signal path.

3.9.8 NO LOCK LIGHT

The NO LOCK Light is on (or blinking) whenever the reference circuits are not operating at the same frequency as the signal applied to the

REFERENCE input connector. Causes for NO LOCK indication are:

1. A frequency change has just been made and the reference loop is reacquiring.
2. The reference input signal is either missing or at too low an amplitude.
3. The reference frequency is outside the operating range of the instrument.

3.9.9 BNC CONNECTORS

There are three BNC connectors on the front panel and four on the rear panel. The signal to be measured is either connected to the front or rear panel input connector. Both input BNC's and the current preamp output BNC have shells wired to the floating ground and if one is grounded the other will not be floating. To maintain a minimum of ground loops there should be only ONE connection to the floating ground. The reference signal is connected to the REFERENCE input connector on either the front or the rear panel. The current preamplifier has a rear panel output connector with a 1K output impedance. It is included for use in dual beam optical systems in which another lock-in is monitoring the same detector. The last two connectors are the output BNC's on the front and rear. These are for driving a monitoring device such as a chart recorder. Unlike the input connectors, these are not paralleled but have an individual 1K resistor in series with the center conductor.

⚠ Maximum levels which can safely be applied to these inputs are discussed in Section 3.8.

3.9.10 DPM DIMMER

This control is located to the left of the analog meter and is used to vary the optical intensity of the digital panel meter. In optical experiments the multiplexed output from this meter can be sensed by a photo multiplier or equivalent optical sensor which might cause an interference with the input of the lock-in. Also the display when viewed in the dark is much too bright to be viewed comfortably.

3.9.11 NORMAL/OPTION SWITCH

This switch is used to connect the output circuit to either the vector summer in normal or to the ratio or log option in the option position. See Sections 3.10 and 3.13 for further information.

3.9.12 AUXILIARY POWER CONNECTOR

The rear panel AUXILIARY POWER CONNECTOR makes available ±16 volt power and signal ground for use in remote preamplifiers.

The pin connections are:

Pin #1	+16V
Pin #2	-16V
Pin #3	Ground

The available output current is 100Ma maximum at each voltage.

3.9.13 POWER INPUT CONNECTOR

The POWER INPUT connector contains a fuse and a small printed circuit card. The position of the card determines the line voltage range.

Follow the procedure in Section 2.3 for changing the voltage range.

3.10 OPTION 02EO - RATIOMETER

3.10.1 RATIOMETER CONTROLS

The Ratiometer Option 02EO is mounted on the rear panel of the 397EO.

It automatically computes the ratio $(\frac{X}{Y})$ of two voltages and produces a voltage proportional to that ratio.

The numerator of the ratio $\frac{"X"}{Y}$ is supplied by the output of the 397EO containing the ratiometer. The denominator is supplied via the Y input BNC connector on the ratiometer. It is usually supplied by another 397EO, an ITHACO Model 395 or an ITHACO Model 164A Preamplifier, but other sources may be used. Note that the denominator Y must be a positive voltage.

The 10 turn potentiometer on the ratiometer is a normalization adjustment. It provides a 10 dB continuous gain adjustment on the denominator or external term.

The 397EO is equipped so that the ratio operation may be preformed either before of after the zero suppress. When the ratio is before the zero suppress, the zero suppress may be used to reduce the output of the lock-in in a mathematically meaningful way. That is, after the result has been normalized to full scale, it may be suppressed by a constant percentage of full scale. The ratio can also be performed in the traditional manner after the zero suppress, in which case, the zero suppress can not normally be used without introducing errors in the reading.

The 397EO is shipped with the ratio before the zero suppress. Refer to Section 5.13.3.1 for instructions to move it after the zero suppress.

3.10.2 NORMALIZATION

The ratiometer option is designed for use in experiments such as "double beam". It has the advantage of allowing the effects of certain uncontrolled variables (such as source intensity fluctuations) to be continuously eliminated from the data.

In many experiments, it is first necessary to normalize the setup, (i.e. define the ratio 1/1). It is recommended that the REFERENCE signal be used as a denominator since it is likely to be more stable than the experiment signal. The denominator (Y) signal should be as large as possible (10V max) for maximum accuracy, although sufficient margin should be reserved if it is expected that the signal will increase during the experiment.

Normally the Y input will be adjusted, by means of the rear panel control, for a ratio of 1/1 or 100% as observed on the front panel meter at full scale. The experimenter may normalize to other points on the dial, but the RATIO output voltage will not provide a direct reading, although it will still be linearly proportional to the ratio. In addition, the experimenter will have to keep track of the R = 1/1 point.

To normalize an experiment, first set up the standard or reference conditions. Adjust the reference channel gain until the Y input is at the desired level, Y_n (10 volts maximum). A Y_n of +5 to +10 volts is recommended for maximum accuracy, although lower levels may be used. Next adjust the 397EO gain, in the non-ratio mode, for an output near full scale (or the desired reference point). Then, go to ratio mode, and adjust the 10 turn pot on the ratio option to give the 1/1 (full scale) output on the meter. If the reference input was less than the recommended 5 volts, it may be necessary to reduce the 397EO gain to compensate.

3.10.3 X, Y, X/Y DYNAMIC RANGE

Although the 397EO and ratiometer will not be damaged if the X, Y, and X/Y terms exceed their range, the accuracy will be degraded. The X/Y term can not exceed 100% full scale on the meter (10 volts on front panel OUTPUT) without accuracy being degraded. The Y term should be between 0.1 volts and 10 volts with values near 10 volts being recommended.

The allowable values of X depend upon the choice of normalization conditions. For example: it will not be possible to adjust for a ratio of 1/1 if X is less than 1/2 the Y input.

Note that it is acceptable to change the gain of the X and/or Y channels during an experiment as long as the resulting ratio is multiplied by the appropriate constant, and as long as it is remembered that the ratio accuracy will be degraded by the gain accuracy of the channels.

For example, suppose that it is found that the source intensity in a dual beam experiment has dropped 20 dB from the value at normalization. The X and Y channel gains may be increased 20 dB each without normalization of the experiment as long as it is acceptable that the X/Y accuracy has been degraded by the gain accuracy of X and Y channels. The wide dynamic range of the ratiometer should allow such gain changes to be eliminated in most experiments.

3.10.4 SPECIFICATIONS

Accuracy (25°C ±5°C):	Ext. input 0.1 to 10VDC	±2%
Input Impedance:	($0 < V_{in} < 12$ VDC)	300KΩ minimum 2M typical
Input Voltage (X or Y):		12V maximum

(Ratio adjustable to unity for $0.5X \leq Y \leq 2X$)

3.11 OPTION 06 - PROGRAMMABLE GAIN (See Table 3.3 for pin connectors and Table 3.4 for Truth Table)

3.11.1 DESCRIPTION

The Programmable Gain Option allows the user to control the gain of the lock-in by rotating the sensitivity switch to the "R" position. In this position, the option is activated, and the SENSITIVITY and EXPAND X10 functions are controlled by the signals applied to the rear panel connector. All signal inputs and outputs are positive - true logic (+5V = true) and all outputs are capable to driving two standard TTL loads. These outputs are protected against short circuits to ground.

The function of each signal is described below:

GAIN CONTROL LINES G_A, G_B, G_C (J15, pins 22, 21, 20)
When the option is activated, these lines control the SENSITIVITY SWITCH function. The coding on these three lines is in a BCD type format such that G_A, G_B, and G_C represent values of 1, 2 and 4 respectively. The effective sensitivity switch setting in volts is then equal to 1 microvolt times 10 raised to the power represented by G_A, G_B and G_C.

$$\text{F.S. (volts)} = 1\mu V \times 10^{(G_A + 2G_B + 4G_C)} \quad \text{(not expanded)}$$

For example, if G_A, G_B and G_C equal 1, 1, and 0 respectively, then the full scale voltage is $10^3\mu V$ or 1mV. The two exceptions to this rule are (0, 0, 0) and 1, 1, 1). These represent invalid sensitivity settings, and in these cases, the lock-in gain is set to 0. When expanded, the sensitivity changes by a factor of 10 to become:

$$\text{F.S. (volts)} = 0.1\mu V \times 10^{(G_A + 2G_B + 4G_C)}$$

Combining both equations gives:

$$\text{F.S. (volts)} = 1\mu V \times 10^{(G_A + 2G_B + 4G_C \text{ - Expand})}$$

The input lines are relatively high impedance, and can be driven by either CMOS or TTL logic. When the option is activated, there is a pullup resistance to +5 volts of 1 meg Ω , and when the option is not activated, the pullup resistance is approximately 50K Ω . When no input is connected, the gain control input default values are (1, 1, 1), and the lock-in gain is set to 0.

EXPAND INPUT (J15, pin 19) - When the option is activated, the EXPAND input (EXP) controls the EXPAND X10 function. In this case, when the EXP signal is true, the output is expanded by a factor of 10. The input is high impedance with a 1MΩ pullup resistor to +5 volts.

EXPAND OUTPUT (J15, pin 1) - The EXPAND signal is functionally identical to that described in the BCD Option, Section 3.11.1. Regardless of other states in the option, this output indicates whether the lock-in is EXPANDed or not.

DATA VALID SIGNAL (J15, pin 4) When the Programmable Gain Option is implemented without the BCD Option, this output is always true when the lock-in is turned on. Thus, the lock-in can be tested to see whether it is powered up. When both the BCD and Programmable Gain Options are installed, this signal functions as described in Section 3.11 for the BCD option.

REMOTE OUTPUT (J15, pin 23) - The REMOTE OUTPUT (REM) signal tells the outside world when the programmable gain option is activated. This signal is always true when the sensitivity switch is in the "R" position, and false otherwise. This tells the external circuits when the lock-in is responding to the G_A, G_B, G_C and EXP inputs.

OVERLOAD (OVLD), NO LOCK and GROUND Signals (J15, pins 3, 2 and 24). These signals represent the appropriate conditions in the lock-in, and are described under the BCD Option (Section 3.11).

See Table 3.4 - Truth Table for Programmable Gain Option

3.11.2 GAIN CONTROL INPUTS AS STATUS OUTPUTS

As a result of the implementation, the GAIN CONTROL LINES G_A, G_B, G_C may be used to sense the SENSITIVITY SWITCH setting when the option is deactivated (i.e. when the SENSITIVITY SWITCH is not in the "R" position). These signals are positive true logic, and are coded as described in Section 3.12.1. The only restriction to the use of these lines is that the output impedance is 50KΩ . Therefore, High input impedance devices (e.g. MOS) must be used to sense the state of these outputs. Also, care should be taken to avoid stray pickup on these lines.

ITHACO 397EO LOCK-IN AMPLIFIER

AUXILIARY CONNECTOR J15

Pin No.	PROG Opt 06	397EO
1	EXPAND STATUS	+5 = EXPANDED
2	NO LOCK	+5 = NO LOCK
3	OVLD	+5 = OVLD
4	DATA VALID II	
5	--	+5 = POSITIVE
6	--	
7	--	
8	--	
9	--	
10	--	
11	--	
12	--	
13	--	
14	--	
15	--	
16	--	
17	--	
18	--	
19	EXPAND CONTROL	+5 = EXPAND
20	GAIN IN: G_C	
21	G_B	
22	G_A	
23	REMOTE STATUS	+5 = REMOTE
24	DIGITAL GROUND	

"1" = 5V
"0" = 0V

DATA VALID II Relates to POWER ON/OFF

TABLE 3.3

SWITCHES		INPUTS				OUTPUTS					LOCK-IN	
EXP. SWITCH	SENS. SWITCH	EXP	SENSITIVITY G_C	G_B	G_A	SENSITIVITY G_C	G_B	G_A	EXPAND	REM	SENSITIVITY	EXP
	1V	X				1	1	0		0	1V	
	.1V	X				1	0	1		0	.1V	
	10mV	X				1	0	0		0	10mV	
	1mV	X				0	1	1		0	1mV	
	.1mV	X				0	1	0		0	.1mV	
	10μV	X				0	0	1		0	10μV	
1	1V to 10μV	X	X	X	X				1	0		X10
0	1V to 10μV	X	X	X	X				0	0		X1
X	R		1	1	1					1	OFF	
X	R		1	1	0					1	1V	
X	R		1	0	1					1	.1V	
X	R		1	0	0					1	10mV	
X	R		0	1	1					1	1mV	
X	R		0	1	0					1	.1mV	
X	R		0	0	1					1	10μV	
X	R		0	0	0					1	OFF	
X	R	1							1	1		X10
X	R	0							0	1		X1
X	R		OPEN	OPEN	OPEN					1	OFF	

X = don't care 1 = true (high)
0 = false (low) ☐ (blank) logic not related

TABLE 3.4 TRUTH TABLE FOR PROGRAMMABLE GAIN OPTION - 397EO

3.11.3 SPECIFICATIONS

Input Levels:	V_{IL}	0V min	1.3V max
	V_{IH}	3.5V min	5V max
Input Impedance:		40kΩ	

Output Levels: "REMOTE" & "EXPAND" Outputs:

V_{OH}	5V nom	
V_{OL}	0V	
I_{OH}	-800μA min @ V_o = 3.5	} 2 TTL
I_{OL}	3.2mA min @ V_o = 0.4V	} Loads

Sensitivity Inputs:

V_{OH}	5V nom
V_{OL}	0V nom
I_{OH}	-20μA @ V_o = 3.5V
I_{OL}	+20μA @ V_o = 1.5V

Gain Accuracy and Linearity: errors caused by this option as compared to normal lock-in operation are less than 0.2% of reading

Input Connector: 24 pin Micro Ribbon *

* Registered trademark of Amphenol

3.12 LOG OPTION 09EO

3.12.1 DESCRIPTION

The Log Option provides the user with an output which is the log of the normal lock-in output. The output scale factor is 1 volt per decade, and the zero output reference point is 1% of full scale on the 397EO. Thus, a 1% reading on the DVM would become a 0.0 volt output from the Log Option, while a 100% lock-in output would produce a +2.0 volt log output. The result of the Log Option can be viewed on the 397EO front panel meters by throwing the OPTION SWITCH from the Normal to the Option position. The scale factor on the meters is then different, because they represent a voltage rather than a percent of full scale. As a result, a 1 volt log output will appear as +10% at the front panel and a 2 volt output will appear as +20% at the front panel. In the case where the Log Option produces a negative result, (such as -1 volt for 0.1%

lock-in output), the DVM will respond correctly with a -10% reading, but the Analog meter will be pinned negative. The rear panel Log Output BNC will swing both polarities and has an impedance of 1.00kΩ.

3.12.2 UNDERSTANDING ERROR SPECS

The specifications for the 397EO Log Option are all referred to the lock-in input, and represent the maximum error as a percentage of the lock-in reading. As an example, if the lock-in were set to 1 volt full scale, and a 0.1 volt signal were applied to the input, the lock-in would be seeing a 10% of full scale signal. At 10% of F.S., the log error spec is 3% of reading. Thus, the log output will say that the lock-in error is 10% ± (3% of 10%) or (10 ± 0.3)%.

A fundamental characteristic of the log operation is that a percentage of reading at the input can be represented by an offset at the output. Therefore, if it is preferred to know the error referred to the output rather than the input, this can be calculated as follows:

1. Take the input error as a decimal fraction, and add 1.0.
2. Take the log to the base 10 of this number.
3. The result is the output error in volts.
   Example: 3% error referred to the input gives:

$$\log_{10}(1.03) = \pm.0128 \text{ volts error at the log output}$$

Input Error % of Reading	Output Error
±1%	±4.3mV
2%	8.6mV
3%	12.8mV
5%	21.2mV
10%	41.4mV

TABLE 3.5 OUTPUT ERRORS COMPARED TO INPUT ERRORS

3.12.3 SPECIFICATIONS

Output Scale Factor — 1V/decade
Zero Output Reference Point — at 1% Full Scale
Accuracy (including lock-in errors in normal mode) referred to lock-in output

Output Level	1%	10%	100%
Error at 25°C (% of reading)	±10%	±3%	±2%
Temp Coefficient of Error	±0.5%/°C	±0.3%/°C	±0.2%/°C

3.12.4 USING OPTION 09EO FOR LOG-RATIO

The Log Option is equipped so that the log-ratio operation can be performed using two lock-ins, if both are equipped with the Log Option. The user simply connects the Log Output from the denominator lock-in to the Log Input on the numerator lock-in. The Log Output of the numerator lock-in is then the log of the ratio of the numerator divided by the denominator, if both lock-ins are set to the same sensitivity. For different sensitivities on the lock-ins, simply add or subtract 1.0 volts for each decade that the sensitivity switch settings differ by.

When the Log Input and Log Output are cross-connected, a voltage divider is formed between the 1KΩ output impedance of one option and the 9KΩ input impedance of the other. Therefore, if the Log Output of the denominator lock-in is observed, the output will be 90% of the reading expected. The front panel reading, however, will not be affected.

3.12.5 dB OUTPUT USING THE LOG OPTION

The 09EO Log Option can be modified so that the output scale factor is 2 volts per decade rather than 1 volt per decade. This is done by clipping out a jumper. (See modification instructions, Section 5.14.2).

When this is done, the front panel meters now read directly in dB compared to 1% of full scale. If this modification has been performed on the denominator lock-in, and the log-ratio function is desired, it then becomes necessary to connect a 10.00k0.1% resistor between the 09EO Options rather than a wire.

SECTION 4

TROUBLESHOOTING THE 397EO

4.1 GENERAL

The information provided in this section should enable an electronic technician to quickly localize the most common malfunctions of the 397EO. The procedure should be used as a guide to aid in isolating a problem.

⚠ WARNING - Dangerous voltages may be present inside the lock-in. Refer servicing to qualified personnel. Always remove high voltage signal inputs and AC power before opening the unit.

4.2 INSTRUMENTS REQUIRED

Digital DC Voltmeter, 4 1/2 Digit
Audio Generator
AC Voltmeter
10 dB Step Attenuator 0 - 80 dB, .02 dB accuracy
Dual Trace Oscilloscope with 10:1 probe
Frequency Counter
Ohmmeter

4.3 SIMPLIFIED SCHEMATICS (Operation)

4.3.1 SIGNAL PROCESSING

Figures 4.1 and 4.2 are simplified schematics of the signal processing and reference processing circuits of the 397EO. They are intended to provide a bridge between the block diagram of Section 3 and the Schematics in Section 7. Primary gain determining components are shown and labeled in the same manner as on the schematics. Each section is isolated by dotted lines and labeled with sheet numbers that correspond to the appropriate detailed schematics. Gain blocks are shown as operational amplifiers although many are made with discrete components. The mixers are shown as DPDT switches to better illustrate their function. Numbers and letters in brackets, such as (3-C) are column and row locators to enable the reader to go from one point in the drawings to another without hunting through all of the drawings. A nearby sheet instruction (either written as, for instance, sheet 6 (4-D) or 6-4D directs the reader to Sheet #6, Row D, Column 4).

Figure 4.1 shows the signal processing circuits in the 397EO. The signal input and the preamps are in the upper left hand portion of the drawing. The preamp gain switching is shown in simplified form with labels beside the switch contacts showing the applicable gain settings.

The low pass filter provides a 0.05 dB ripple 3-pole Chebyshev response

with cutoff located at about 12 kHz. The filter has a 6 dB/octave low frequency rolloff provided by U3.

The first mixer is a balanced mixer consisting of two DPDT reversing switches, Q13 - Q16. The switches are opened and closed at the frequency "f_V" from the VCO and $\div 2$ circuits shown on Figure 4.2. If the mixer is perfectly balanced and the input signal is pure, the mixer output will consist of the frequencies $(2N+1)(f_V) \pm f_S$, where $0 \leq N \leq \infty$ and N is an integer. "f_S" is the signal frequency. "f_V" is the I.F. frequency, 31 kHz. Thus the lowest frequency out of the first mixer is at the I.F. frequency.

The bandpass filter is an active bi-quad filter. The filter has a Q of about 18 and a voltage gain of about 40, when combined with the Diff Amp preceding it. Since the lowest frequency into the bandpass filter is at the "f_O" frequency, a true bandpass response is not required. Consequently, the low pass outputs are used to provide a sharper cutoff of higher frequencies.

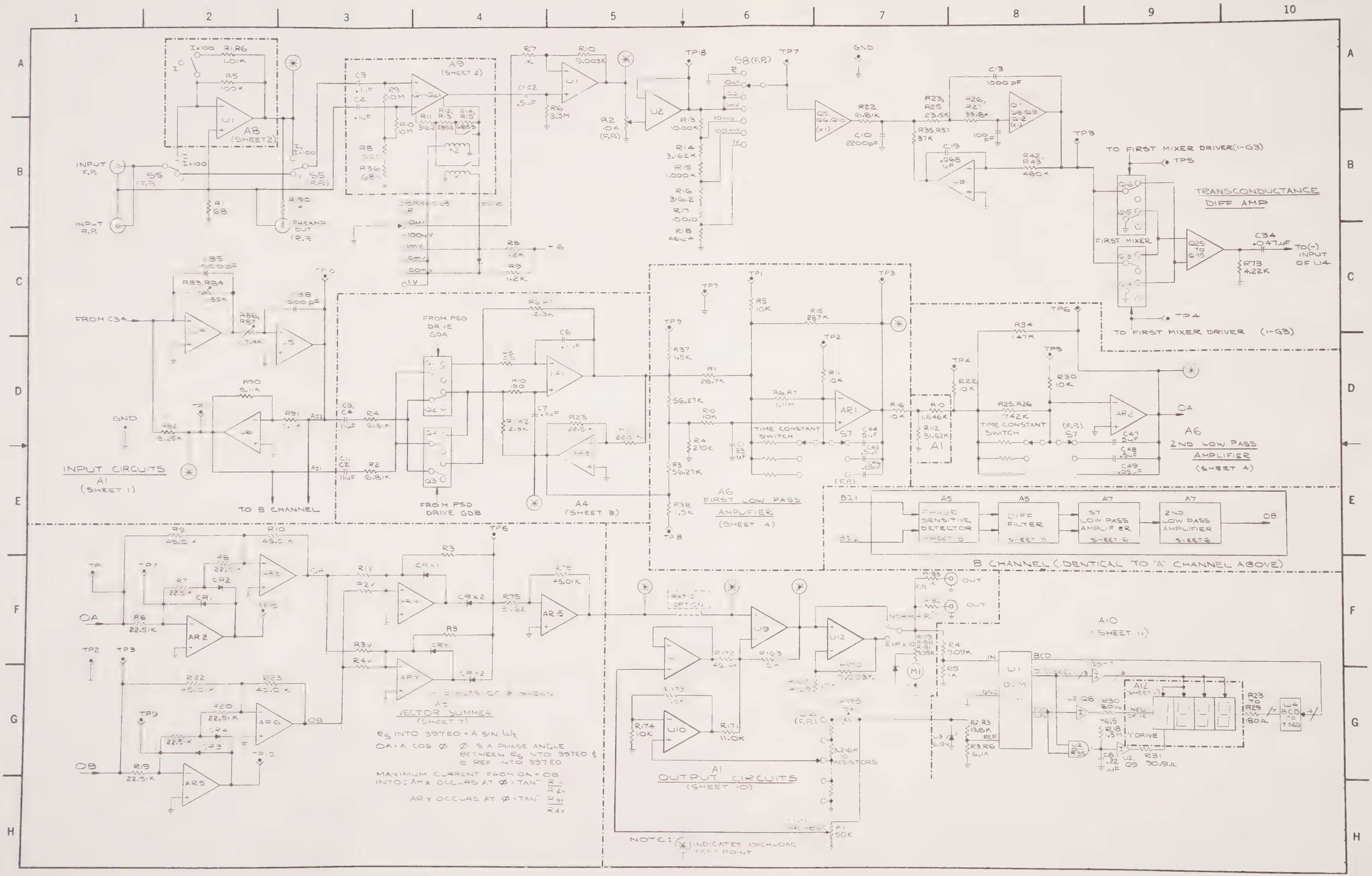
At 10 kHz, most of the signal out of the bandpass filter is at the "f_O" frequency. As the signal frequency is reduced, more of the $f_V + f_S$ signal appears in the output of the bandpass filter. Thus one should not be alarmed to see a typical two toned signal out of the bandpass filter. Only the $f_V - f_S$ signal is demodulated by the phase sensitive detectors.

The two phase sensitive detectors are identical. The only difference between channel A and channel B is the phase relationship to the detector drive signals. The intergrator U6, Figure 4.2, provides almost a 90° phase shift between its input and output signals. Its output signal is used to drive the B channel phase sensitive detector. Because the phase sensitive detectors are driven in quadrature, the output of one channel is proportional to $\sin\phi$ and the other is proportional to $\cos\phi$, where ϕ is a phase angle between the signal and reference inputs.

The output of the phase sensitive detectors is first filtered by a fixed 1.25ms differential filter. It should be noted that this "pre filter" is always present. Usually it has negligible effect, but it will add a significant additional 6 dB/octave rolloff if wide bandwidths are being used. The time constant switching of the output low-pass filters is shown in a simplified form similar to the preamplifier gain switching. There are only 3 out of 9 positions shown for simplicity.

The low-pass amplifier outputs go to the vector summer. The vector summer extracts the amplitude of the signal being monitored by the 397EO. The signals are first passed through absolute value circuits.

For simplicity, only two sections of the eight section vector summer are shown in Figure 4.1. Assume $0A = A\cos\phi$ and $0B = A\sin\phi$.



ITHACO DWG D42056, SH 1, 5/78

FIGURE 4.1
SIMPLIFIED SCHEMATIC
SIGNAL PROCESSING

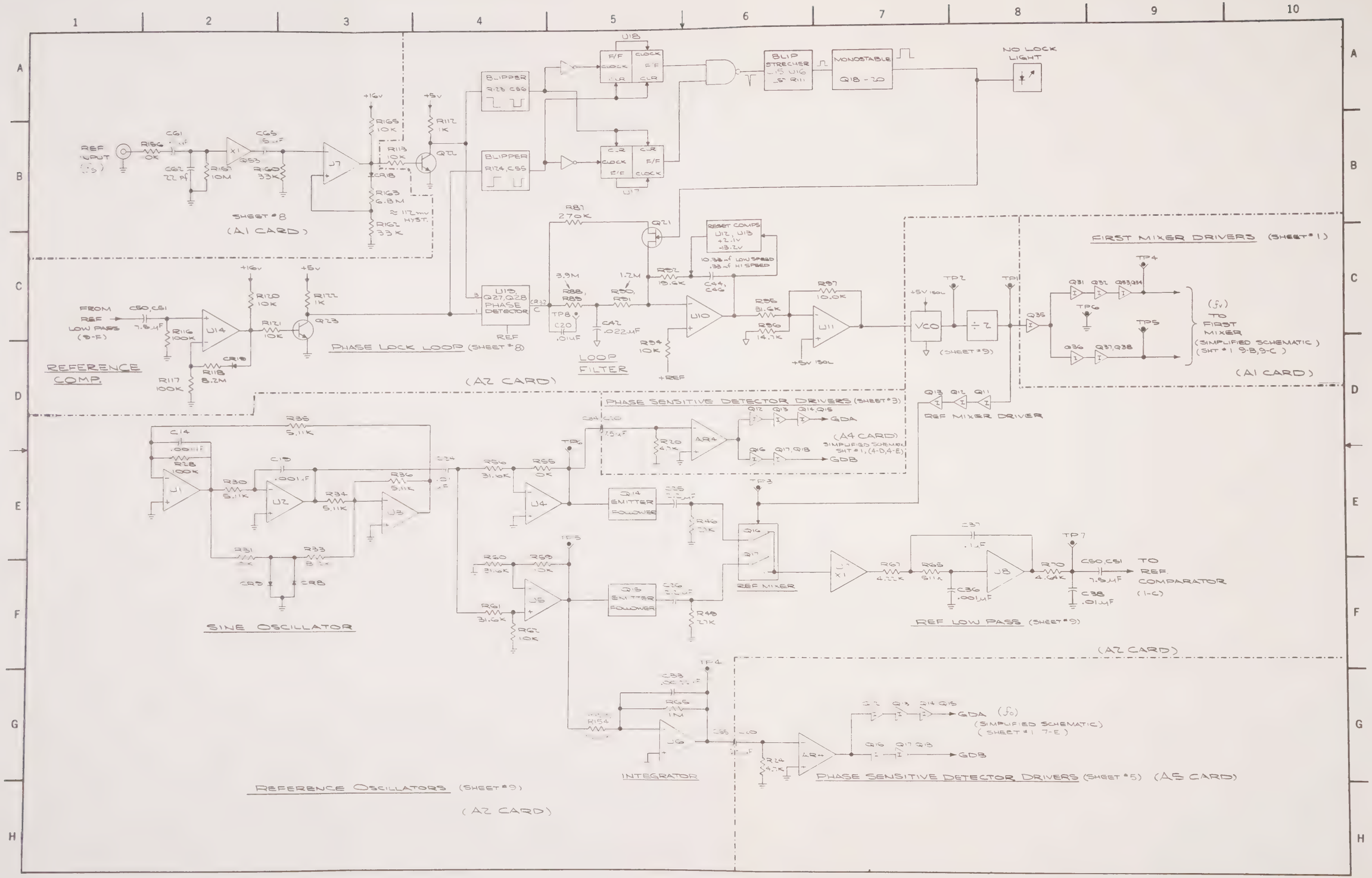


FIGURE 4.2
SIMPLIFIED SCHEMATIC
REFERENCE PROCESSING

ITHACO DWG D42056, SH 2, 5/78

Then the signal input into ARX is given by:

$$I_{in} = \frac{A \cos\phi}{R_{1V}} + \frac{A \sin\phi}{R_{2V}}$$

Max/Min theory shows that the maximum input current occurs at a phase angle which is given by:

$$\phi = \text{arc tan } \frac{R_{1V}}{R_{2V}}$$

Similarly, the maximum current into ARY occurs at

$$\phi = \text{arc tan } \frac{R_{3V}}{R_{4V}}$$

Diodes CRX2 and CRY2 select whichever output is maximum and supplies that signal to R75. In the actual circuit, the 0° to 90° quadrant is divided into 8 segments. The input resistors for each op amp are selected so that a maximum input current for one of the op amps occurs at the midpoint of each segment.

The output of the vector summer thus represents the amplitude of the input signal into the 397EO. In the output circuits, U9 adds the zero suppression from both the stepped switch and the vernier pot zero suppress. U9 also amplifies the vector summer or the ratio option output depending on the position of the normal-ratio switch on the front panel. The output expand switch connects the meters and the output BNC's to either the output of U9 or U12 of the expand X10 amplifier.

It should be noted that it is necessary that the bandwidth time constant setting be low enough to remove output ripple due to noise or asynchronous signals. Excess ripple in the 0A and 0B signals may be rectified by the absolute value circuits and interpreted as additional signal by the vector summer.

4.3.2 REFERENCE PROCESSING

The reference processing circuits in the 397EO are shown in Figure 4.2. The reference input is at the upper left hand portion of the drawing.

The external reference signal is AC coupled to comparator U7. U7 is wired as a zero crossing detector. The positive going transition out of U7 coincides with the negative going transition of the input signal.

The output of U7 is inverted and conditioned to TTL logic levels by Q22. The output of Q22 is fed to the phase detector U19. There the negative transitions from Q22 and Q23 are compared. The output of U19 (at TP 8) is a train of pulses whose duration and polarity is proportional to the time difference between the negative transitions at the input.

It should be noted that the output of U19 is open between pulses. One must exercise care in troubleshooting not to disturb the loop filter by loading the U19 output with a d.c. load such as may be presented by an oscilloscope probe. For this reason, AC coupled TP8 is provided.

U10 is the loop filter amplifier. The filter smooths the phase detector output and provides an error signal to U11 and thus the VCO. The rather specialized grounding and +5 volt connections are required to reduce VCO jitter. Reset comparators U12 and U13 prevent the loop filter from going outside the proper operating range.

The VCO output drives a bistable ($\div 2$) circuit. The bistable is required in order to ensure that the two mixers will receive a precise square wave drive. The bistable output is at the frequency "f_v" discussed earlier

The sine oscillator (f_o) determines the I.F. frequency for the instrument. The nominal I.F. frequency is 31.5 kHz. Amplifiers U4 and U5 develop the two phases required for proper drive of the first mixer. The emitter followers prevent mixer transients from interfering with the operation of U4 and U5.

The reference mixer operates in a manner similar to the operation of the first mixer in the signal processing loop. The reference mixer is not as complex since maintaining careful mixer balance to eliminate the frequency f_v is not critical. The mixer output consists of signals at the frequencies $(2N+1)\ (f_v) \pm f_o$.

The phase lock loop filter is a 3-pole 3 dB ripple low-pass Chebyshev Filter. It strips off all but the lowest mixer output frequency $f_v - f_o = f_s$. Comparator U14 detects the negative going zero crossing for use in the phase detector U19.

U6 looks like an inverting amplifier. Capacitor C33 is large enough so that the circuit behaves very nearly like a true integrator. R65 provides dc feedbacks to prevent the integrator from drifting into the supplies. The theoretical phase shift is 89.87° vs 90° for a true integrator.

The output of the integrator goes to the A5 card which is the B channel phase sensitive detector. The output of U4 leads the output of U6 by 90°. Thus U4 and U6 drive the A and B phase sensitive detectors in quadrature.

4.4 HOW TO PROCEED WITH TROUBLESHOOTING

To aid in fault finding, a block diagram is included in Section 3. Simplified schematics Figure 4.1 and 4.2 are included in this section. They show primary function components and are a handy reference for locating the appropriate detailed schematic.

Before proceeding further, remove the top cover. Look for any loose wire, broken

solder joints, stray shorts due to debris or burned components. Next apply power and check the ±16 volt and +5 volt supplies. The ±16 volt supply should be within ±2% and the +5 volt supply should be between +4.75 volts and 5.25 volts.

4.5 STANDARD CONDITIONS

The 397EO should first be checked under the following standard conditions:

Time Constant	.25
Zero Suppress	OFF (No light)
Sensitivity	10mV
Power	ON
Gain	10.0 (full cw)
Input	V Mode
Output	Normal
Normal/Option	Normal
Dim	Full cw

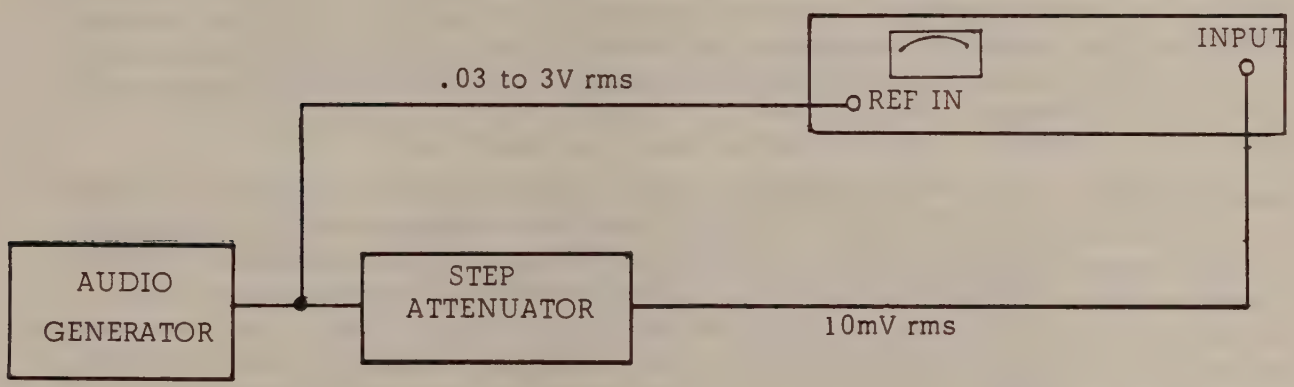


FIGURE 4.3 STANDARD SETUP

Connect the 397EO as shown in Figure 4.3 and let it warm up with the top cover in place for at least 30 minutes. Adjust all controls to the standard conditions. Supply 1 kHz signals as shown in Figure 4.3. A properly operating 397EO should show a positive full scale reading on the front panel meter. No front panel red or yellow lights should be on.

4.6 REFERENCE CIRCUITS

4.6.1 If the 397EO does not give the proper output indication as indicated above, then on must try to isolate the malfunction. With the unit set up as above, first attempt to isolate the problem to the reference or signal processing circuits. If the No Lock light is on monitor TP7, the reference low pass output on a oscilloscope. The signal there should be a sine wave which is phase locked to the reference input signal.

Vary the input signal frequency and monitor TP7 on the A2 (rear) board. The signal should go to and lock onto the input signal. If the reference loop appears to be behaving, then proceed to Section 4.7.

4.6.2 Assuming that the reference loop is misbehaving, then perform the following checks:

Monitor the collector of Q22 on an oscilloscope. The negative going transition should coincide with the negative going zero crossing of the reference input signal. Also check the collector of Q23 to see that pulses are appearing there, assuming that the reference low pass output signal is some semblance of a sine wave with at least a 100mV amplitude.

4.6.3 To further check the reference circuits, switch the reference input frequency to 25 kHz. The output of U10 should go negative to around -13.2 volts and then be forced to about -7 volts by the action of the reset comparators. Similarly remove the input signal. The output of U10 should go positive to about +2.1V and then be forced negative by the action of the reset comparators. If the 397EO operates properly except at frequencies near 10 kHz or 10 Hz, then the problem may likely be in the reset comparators. Check for a failed component in these circuits.

4.6.4 If the 397EO appears to operate properly, except that the NO LOCK light stays on, then the failure is in the no-lock circuit. Monitor the outputs of the various circuits to isolate the problem. The R123, C56 circuit generates a 125ns negative blip coinciding with the negative going transition for Q22. The R124, C55 circuit generates a similar blip coinciding with the positive going transition from Q23. The two blip trains clock and reset U17 and U18. If the input and reference signals are at the same frequency, then the second flip/flop in each chip never gets a clock pulse from the first one. Check for steady positive outputs from U17 and U18 into the following gate. That gate output should be always positive if the reference loop is locked. The R111, Q57 circuit stretches any transient out of the gate into a pulse long enough to trigger the Q18-Q20 monostable. That monostable should be holding the output of U9 negative as long as the reference loop is locked. If all these circuits are correct, then check for a failure in the light driver circuit.

4.6.5 The VCO circuit is inside of one of the metal cans. The signal, on TP2 should be a typical multivibrator output signal at the frequency $2f_V$. The $\div 2$ circuit changes the $2f_V$ multivibrator signal into a clean square wave signal at f_V which should appear on TP1.

4.6.6 The sine oscillator under the other can generates a sine wave at the IF frequency 31.5kHz. Check that the signals on TP5 and 6 are clean sine waves at 31 ±1 kHz. The signal on TP4 should lead the signal on TP5 by 90° (A2 board).

4.6.7 When the faulty circuit has been localized, check visually for poor solder joints, broken runs and loose connections. Accurate D.C. voltage and current measurements will usually pinpoint a faulty semiconductor.

4.7 SIGNAL CHANNEL

4.7.1 If the reference circuits work properly, but the meters fail to show the proper readings under standard conditions, proceed as below:

NOTE: It may be appropriate to exchange A4, A5, A6 and A7 plug-in cards during troubleshooting to localize faults. It is important, however, to assure than these cards return to their original locations to insure proper gain match between the in-phase and quadrature-phase channels.

4.7.2 Remove the signal from the input connectors. Turn the Zero Suppress to Zero and OFF. The meters should go to zero volts and zero volts should appear on the front panel output connector. If the output voltage is not zero, readjust pots R184 and R185 according to the procedure in Section 5.9. If the output cannot be brought to zero, then check TP6 on the A6, A7, and A3 cards to see if these points are near 0 volts. If they are, then the output circuit must be defective. If one of the test points in not near zero volts, then the defect is in that channel's low pass amplifier or phase sensitive detector. Careful d.c. and oscilloscope checks should quickly isolate the defect. Test the zero suppress controls at this time. Zero Suppress should force the output negative.

4.7.3 Return to standard conditions. Using Figures 4.1 and the block diagram, trace the signal with the oscilloscope using a high impedance (10:1) probe. Look for abnormal distortion, overloads and gain inaccuracies. Be careful not to short any points together or to ground. Such accidential shorts may damage transistors. It is a good practice to turn the unit OFF before connecting and disconnecting the probe. Be careful not to cause ground loops. It is necessary to be careful that a nearby ground reference be used for the oscilloscope. It is not unusual for example, to find millivolt size transients between the A1 and A3 card grounds.

4.7.4 If the first mixer or the synchronous detectors fail to pass the signal properly, check the gate drive signals. If the gate drive is o.k., remove the MOSFET switching transistors one by one and check for gate to channel breakdown with the ohmmeter.

NOTE: Turn off power, ground yourself to the 397EO chassis and the soldering iron tip when removing and installing MOSFET devices. Never hold the device by the gate lead. When checking for gate breakdown, connect the ohmmeter to source or drain FIRST.

4.7.5 A faulty transistor in the signal low pass filter will usually show up as slightly degraded amplitude and phase response. A degraded transistor can usually be located by careful d.c. voltage measurements. A degraded FET may often be detected by careful gate current measurements.

4.7.6 To check the accuracy of the 397EO preamps, go to standard conditions. With the help of the 10 dB attenuator, check for full scale reading on

the meter in each sensitivity position. The attenuator must be properly terminated, and have better than .02 dB accuracy.

4.7.7 When a faulty circuit has been localized, check visually for poor solder joints, broken runs and loose connections. Accurate d.c. voltage measurements will usually pinpoint a faulty semiconductor.

4.8 CHECKING THE OVERLOAD CIRCUIT

The 397EO is equipped to detect overloads at all points except the output of the expand X10 amplifier in the output circuit. The following procedures may be used to check these overload detectors.

4.8.1 MAIN CIRCUITS AND CURRENT PREAMP

To check main overload circuits set up as shown in Figure 4.4

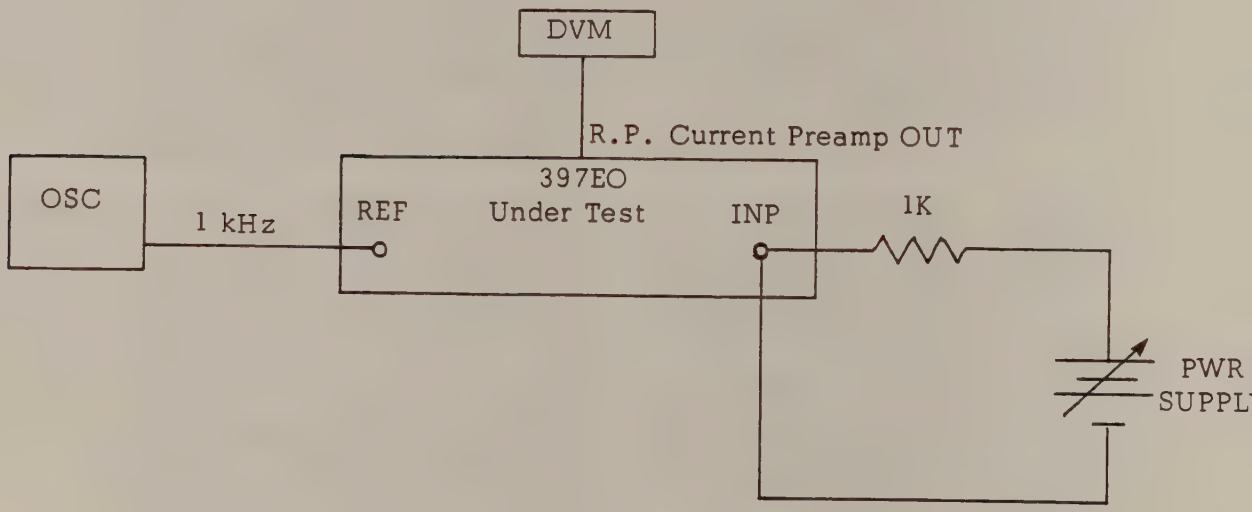


FIGURE 4.4

Set reference frequency to 1 kHz. Set Input switch to I X100 and adjust power supply for approximately 5V. Vary power supply voltage while monitoring DVM on current preamp output. The overload light should go on at 5.4 ±.5V and off at 5.2 ±.5V. Repeat with the power supply leads reversed.

4.8.2 VOLTAGE PREAMP

Set up as shown in Figure 4.5 switching the input to "V" mode and sensitivity to 1V.

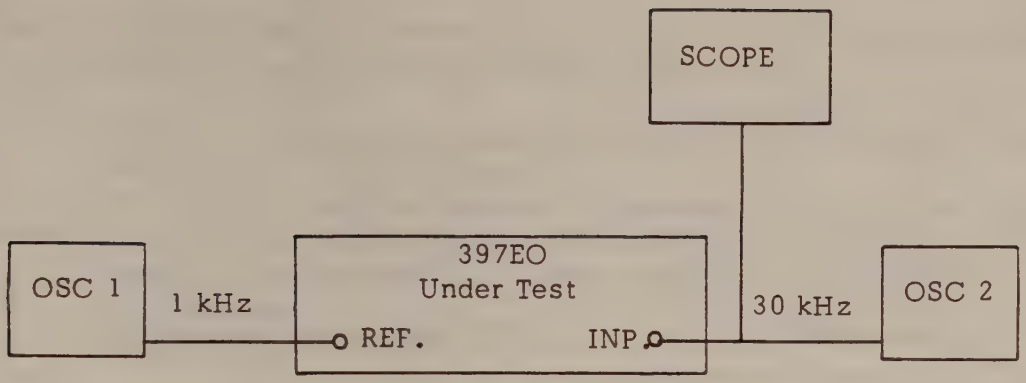


FIGURE 4.5

Monitor input with a scope set for 2V/div and 50μs/div. Adjust OSC 2 for an overload light. It should come on to go about 6 ±.5V peak.

4.8.3 BANDPASS

Using Figure 4.5, set OSC 1 to 1 kHz and OSC 2 to 500 Hz. Set the sensitivity switch to the 10μV position. Set scope to .2V/div and 1 ms/div. Adjust OSC 2 level to the point where the unit overloads. This should occur at 650 ±50μV.

4.8.4 1ST LOW PASS AMPLIFIER

Using Figure 4.5, set OSC 1 to 20 Hz and OSC 2 to 19.5 Hz. Set the Time Constant switch to .0025s and Sensitivity to 100mV. Ground TP6-A6, TP6-A7 and TP3-A6. A signal input of about 1V peak should make the overload light blink at about once per second. Switch ground to the other TP3 on A7. This should also blink once per second at about 1V peak.

4.8.5 2ND LOW PASS AMPLIFIER

Change the Sensitivity to 1V. From the previous step, disconnect the grounding jumpers on TP3-A7 and TP6-A7 (leaving TP6-A6 grounded) and remove jumper block A16 on A1. Using Figure 4.6, set OSC 1 to 20 Hz and OSC 2 to 19.5 Hz. A signal input of 2.5V peak should make the overload light blink once per second. Change ground jumper from TP6-A6 to TP6-A7. This should also blink at the same level and rate. Plug in the A16 jumper block so that 117 and 116 are connected and 125 and 124 are connected. Remove jumper on TP6-A7.

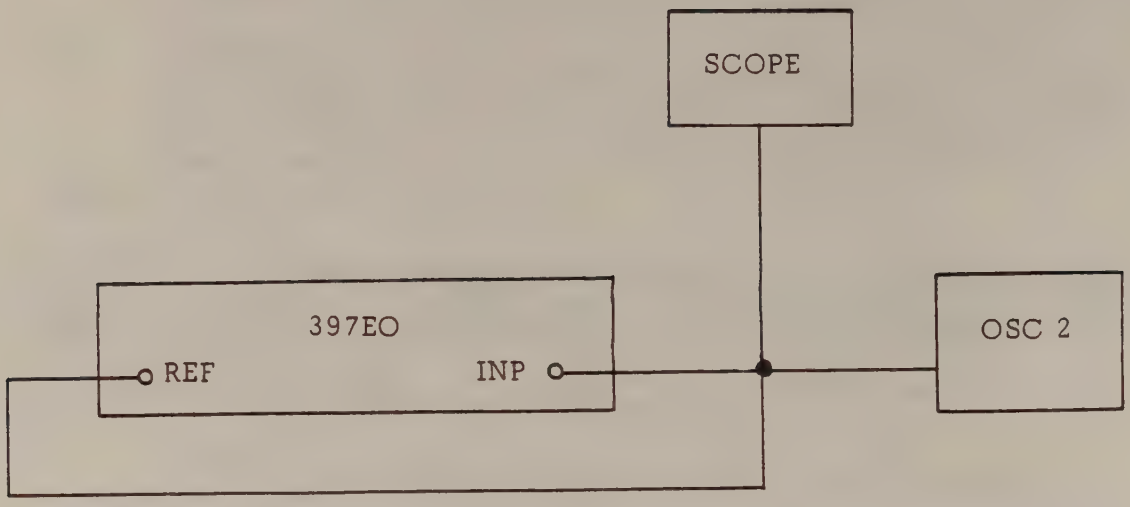


FIGURE 4.6

4.8.6 VECTOR SUMMER

Using Figure 4.6, set the Sensitivity to 1V and the Time Constant to 25s. Connect TP17-A1 to ground. Connect OSC 2 to both the reference and signal inputs and adjust frequency to 1 kHz. Overload should occur at 3.6V peak at the signal input BNC. Disconnect jumper on TP17-A1.

4.8.7 OUTPUT CIRCUITS

Using Figure 4.6, set level of OSC 2 for an overload indication at about 12.5V or 125% on the internal DVM.

4.9 DIGITAL VOLTMETER (Serial Number 65975 and up) earlier models: See Appendix A

The digital voltmeter converts the lock-in output to a digital number and displays this information on the front panel LEDs. The information for this number is provided, via the analog processor (U5), by the digital processor (U6) as a multiplexed series of BCD digits (B1 through B4). These digits are valid within a given time frame (when D1 through D4 are active). U8 converts the BCD information to seven segment data for the displays. Meanwhile, Q2 through Q5 are active at the appropriate time to allow the proper LED to display the necessary information. Because there is no need for an underrange signal provided by U6 (on B4 during D4), the B4 signal to U8 is qualified by D4 and supplied as $\overline{D4}\cdot B4$. Also since D4 need only be active for the "1" output of the MSD LED, Q2 is activated by $\overline{D4}\cdot B1$, eliminating the "0" from causing a "1" to be displayed. The oscillator for the digital processor operates at a high frequency and is divided down to produce the scan rate for D1 through D4. It is further divided down to produce the conversion rate. A complete conversion takes 6144 oscillator cycles; 2048 cycles for auto zero and 4096 cycles for measurement.

Since data is loaded into the digital processor data latches following an override signal, and the BCD outputs are latched and begin strobing during auto zero, and DATA VALID (M/Z) is high only after the auto zero cycle is completed, the DATA VALID signal is, thus, a true indicator of a valid data output.

4.10 RATIO OPTION 02EO

This Option is relatively straight forward and should not cause too many problems. If it is not functioning properly, try the following check list:

a. Verify that the Output Connector Block A16 is in the proper place. (see Section 5.13.3 for details)
b. Check to see that the red wire is attached to +16 volts and the violet wire is attached to -16 volts.
c. Check to see that +9VDC is present on pin 11 of the AD433J Ratio Module.
d. Check the input diodes CR1, CR2 for shorts.

4.11 PROGRAMMABLE GAIN - OPTION 06

4.11.1 DESCRIPTION OF CIRCUIT (Refer to simplified schematic Figure 4.10)

The Programmable Gain Option is located on two cards, the switching card and the interface card. When the BCD Option (05) is also provided, the interface card is replaced by the BCD output card.

When the front panel Sensitivity switch is in the "R" position, the external gain inputs go directly to the BCD-to-gain-switching decoder. The outputs from this decoder then drive the various gain switching elements. The first preamp gain switching is done on the preamp card, while the rest of the switching is done on the programmable gain card. The second preamp is switched by K4 while the attenuator uses both FET's and a relay.

When the Sensitivity switch is not in the "R" position, the REM signal goes high and defeats the external inputs by loading the gain lines with 2.7KΩ resistors. Q2 and Q3 buffer the REM signal for external use. The gain control lines are then pulled down by various contacts on the Sensitivity switch.

The Expand switch function is replaced by 2 relays, K1 and K2. These in turn are controlled by either the Expand switch or the remote input as selected by the data selector (U1). The Expand output is buffered at the interface card.

4.11.2 TROUBLESHOOTING OPTION 06

a. Set the lock-in up with a 10 dB step attenuator connected to the signal input and an oscillator feeding the reference input and the attenuator.

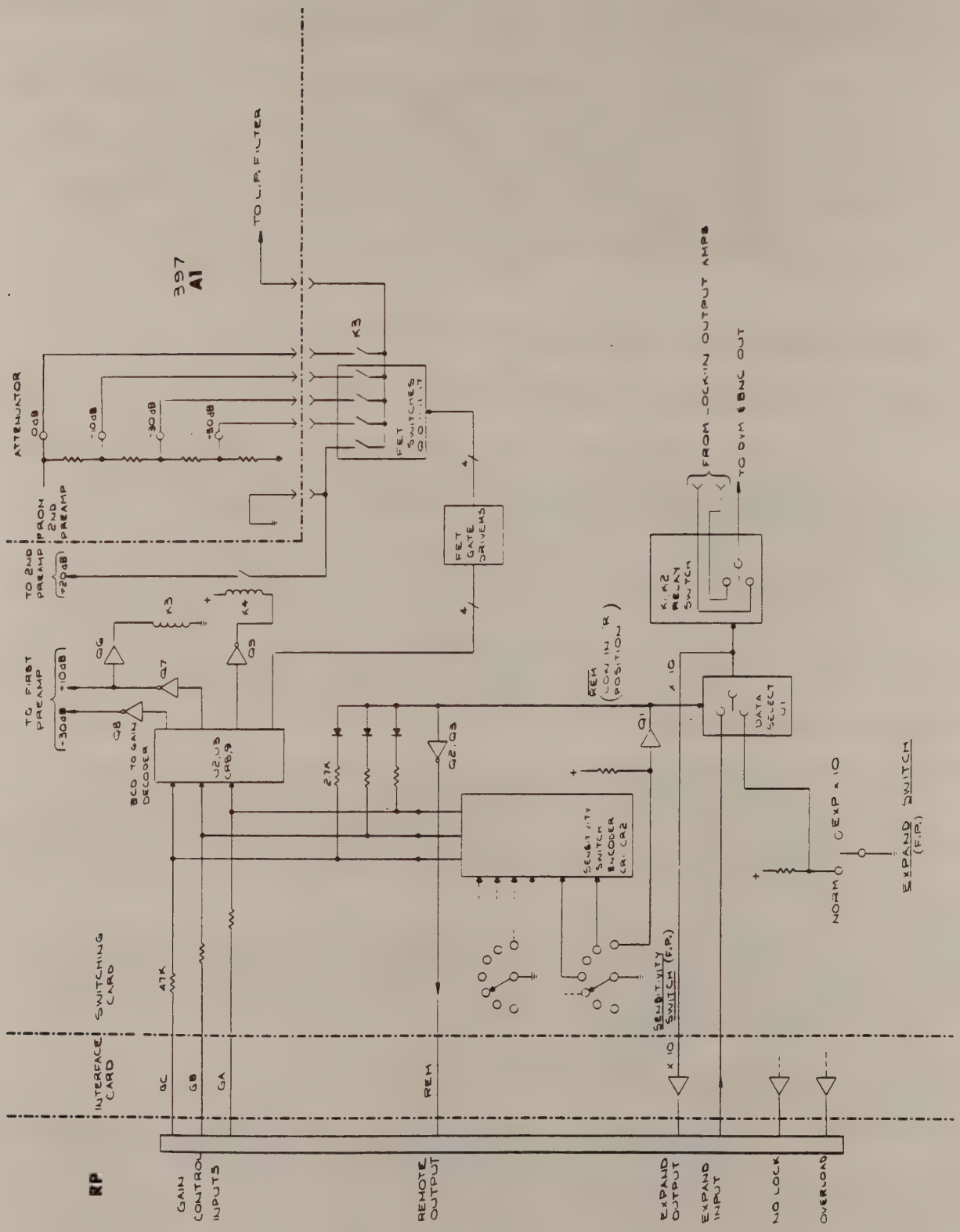


FIGURE 4.7
SIMPLIFIED SCHEMATIC
PROC[illegible]

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b. Step through the Sensitivity switch and Attenuator, (2 steps on Attenuator for each step on Sensitivity switch), and look for gain errors.

c. If the gain is wrong, check to see that the switching code (G_A, G_B, G_C) is correct. These lines may be observed at the rear panel connector.

d. If the gain code is correct, then again refer to Table 4.1 to see which switch functions should be operative and check them. Relay coils are active above about 2 volts, while the FET gate drives go from about +0.7 to -15 volts for true and false states respectively.

e. Go to the "R" position on the Sensitivity switch, and check gain again. Any new problem is likely to be associated with the REM signal.

		PREAMP 1		PREAMP 2	ATTENUATOR				
SENSITIVITY SWITCH	GAIN CODE G_C G_B G_A	+10 dB	+30 dB	+20 dB (k4)	-0 dB (k3)	FETS -50 dB (Q10)	-30 dB (Q11)	-10 dB (Q12)	GROUND (Q17)
*	1 1 1								ON
1V	1 1 0					ON			
100mV	1 0 1						ON		
10mV	1 0 0							ON	
1mV	0 1 1	ON			ON				
.1mV	0 1 0	ON	ON		ON				
10μV	0 0 1	ON	ON	ON	ON				
*	0 0 0								ON

* REMOTE ONLY

TABLE 4.1 PROGRAMMABLE GAIN SWITCHING

SECTION 5

CALIBRATION PROCEDURE

5.1 GENERAL

Complete calibration procedures for the 397EO are given in this section. In order to obtain good results, it is important that each step be followed exactly as stated. Do not attempt any adjustments without the proper equipment. It is assumed that the 397EO is completely working, so no tests for malfunctions are included.

The 397EO should be calibrated whenever critical components have been replaced.

⚠ WARNING - Dangerous voltages may be present inside the lock-in. Refer servicing to qualified personnel. Always remove high voltage signal inputs and AC power while opening the unit.

5.2 TEST EQUIPMENT

Digital AC-DC Volt-Ohmmeter (DVM) (4 1/2 Digits)
2 Sine Oscillators
10 dB Step Attenuator, 0-80 dB ±.05 dB
Oscilloscope with 10:1 Probe

5.3 POWER SUPPLY

Allow the 397EO to warm up for at least 60 minutes.
Use the DVM to measure the +16 volt supply voltage.
Use Pot R132 (A2 card) to set the +16 volt supply voltage to +16 ±.02 volts.
Check that the -16 volt supply is -16 ±0.3 volts.
Check that the +5 volt supply is +5 ±0.25 volts.
The voltages may be measured on terminals 27, 29, and 26 on the A2 card respectively. See Figure 5.1.

5.4 VECTOR SUMMER ABSOLUTE VALUE CIRCUITS

All test points and pots mentioned in this section are on the Vector Summer Card (A3).
Connect TP1 to TP2, TP3 to TP2, TP7 to TP8, and TP9 to TP10.
Adjust Pot R11 until the voltage on TP4 is 0 ±1mV.
Similarly adjust Pot R24 until the voltage on TP5 is 0 ±1mV.
Disconnect the TP7 to TP8 and TP9 to TP10 jumper.
Adjust Pot R3 until the voltage on TP8 is near zero volts.*
Similarly adjust Pot R16 until the voltage on TP10 is near zero volts.*

*NOTE: The inverting op amp is open loop when the output voltages are near zero volts. Thus the voltage will be noisy and fairly unstable.

5.5 VECTOR SUMMER MATRIX

All Pots and test points in this section are located on the Vector Summer Card (A3). Verify that TP1 and TP3 are connected to TP2 and that those are the only jumpers.

Turn Pots R29, R35, R41, R47, R53, R59, R65 and R71 fully counterclockwise.
The voltage on TP6 should be positive.
Adjust Pot R29 clockwise until the voltage on TP6 is 0 ±1mV.
Next adjust Pot R35 slowly clockwise until the voltage on TP6 starts to move further negative.
Similarly, set Pot R41, R47, R53, R59, R65, and R71. These pots are properly set when the voltage on TP6 is 0 ±1mV and turning any one of the Pots more clockwise will cause TP6 to move negative.
Disconnect the TP1, 2 and 3 jumpers.

5.6 LOW PASS AMPLIFIERS

Align the A6 and A7 cards as follows: Designations in parentheses refer to the A7 card. Unless otherwise noted, test points and trim pots are located on the A6 (or A7) card.

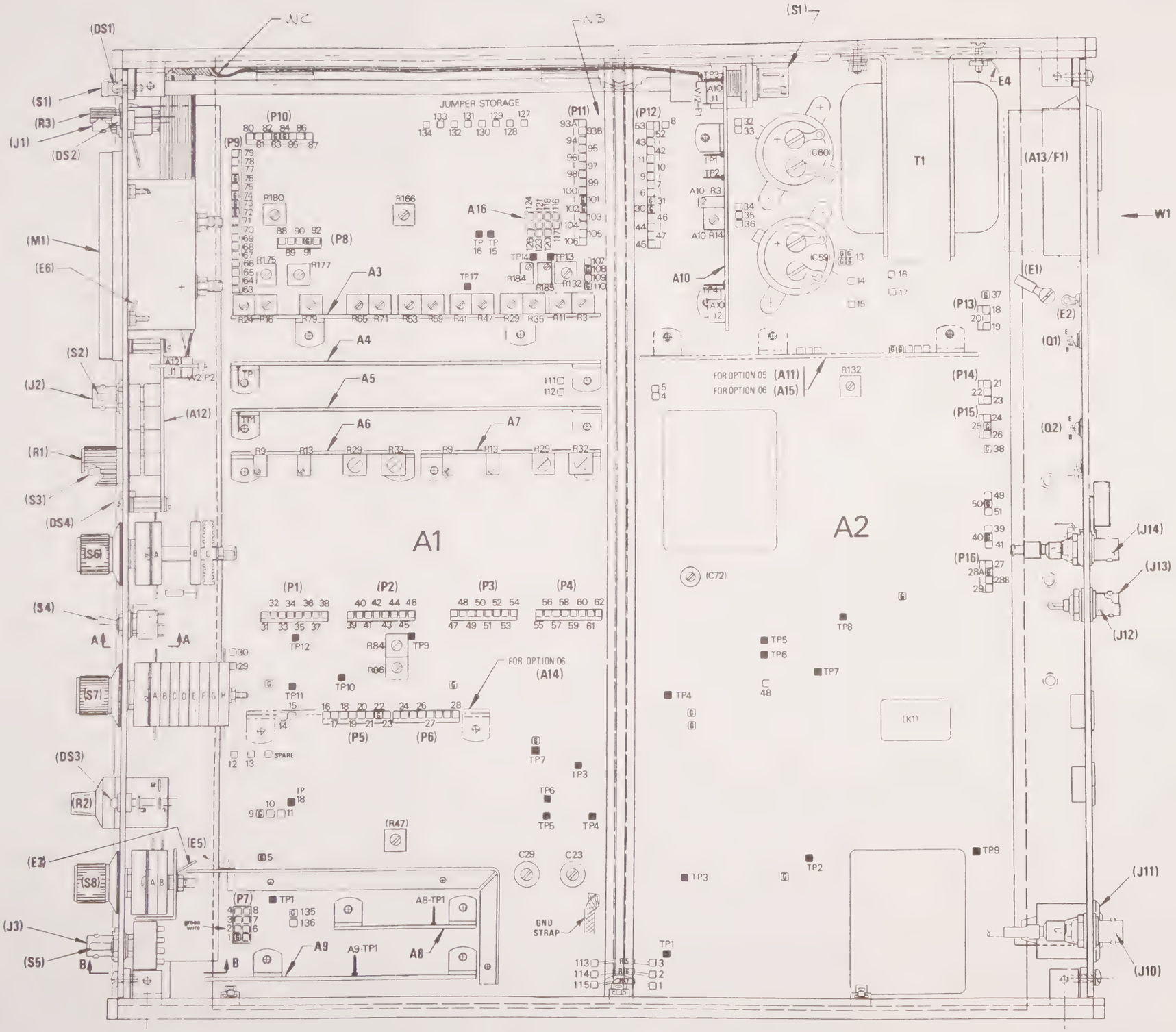
On A1 adjust R184 (R185) for 0 ±1mV on TP9 on A6 (A7).
Set the bandwidth switch to .0025.
Adjust R29 for 0 ±.1mV on TP4 on both cards.
Disconnect plug P2 (P4) on the A1 card.
Adjust R32 until 0 ±.1mV on TP4 is again obtained.
Reconnect the plug P2 (P4) on both cards.
Adjust R9 for 0 ±.1mV on TP1.
Disconnect plug P1 (P3) on the A1 card.
Adjust R13 until 0 ±.1mV on TP1 is again obtained.
Reconnect plug P1 (P3).

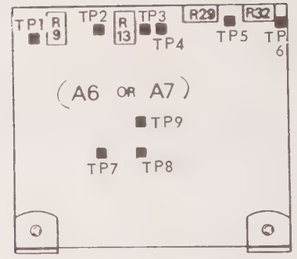
5.7 FIRST MIXER BALANCE

Leave the signal input shorted and the Sensitivity at 1V full scale.
Supply a 500 Hz reference signal.
Monitor the bandpass output, TP10 (A1 card) on the oscilloscope.
Be sure the oscilloscope return is to a nearby ground pin.
The signal on TP10 should mainly consist of the f_V frequency.
Adjust R47 to minimize the bandpass output signal to less than 5mV p-p. If necessary, adjust C21 and/or C27 also.
An inability to reduce the signal to the above level indicates trouble in the mixer, mixer driver or signal low pass circuits.

5.8 OUTPUT ZERO ADJUST

Monitor the front panel output voltage with the DVM.
Switch to .25 second Time Constant and 1V full scale.
Connect a shorting cap across the input and supply a 1 kHz external reference.





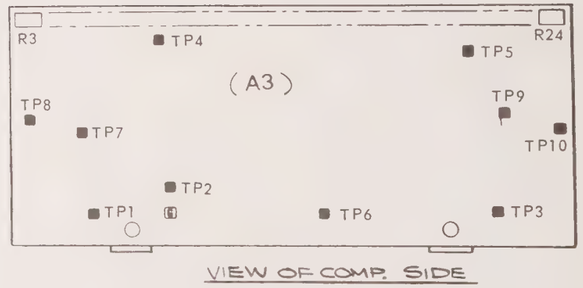


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FIGURE 5.1
LOCATION OF CALIBRATION ADJUSTMENTS AND TEST POINTS

Adjust Pots R184 and R185 (A1 card) until the output is minimum, i.e. most negative or least positive.

5.9 CHANNEL BALANCE

For this adjustment it is necessary to vary the relative phase between the signal and reference inputs. This can be done by using two oscillators set to slightly different frequencies.

Set up the following test set up.

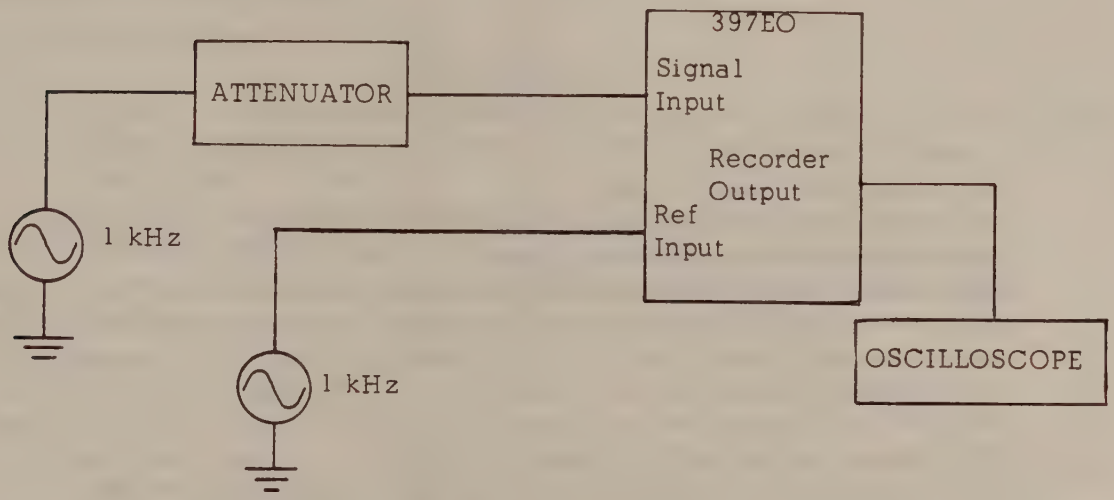

FIGURE 5.2

Set Time Constant switch to .0025 seconds and the sensitivity switch for 100mV.
Adjust signal oscillator and attenuator for approximately 100mV rms out.
Carefully adjust the frequency of the signal oscillator for maximum DC output from the recorder output.
Adjust the oscillator level until the output is 100%. Then move the frequency until the output reduces to 95%.
Turn on the zero suppress and adjust it for zero on the meter.
Set oscilloscope for 50mV/div DC coupled and 10ms/div.
Note that the small ripple resembling the output from A full wave rectifier is approximately 100mV pp and that this ripple is added to a lower frequency ripple. Null out the low frequency ripple by adjusting R132.
If the low frequency ripple cannot be reduced until it is less than 40mV pp, repeat 5.8, Output Zero Adjust.

5.10 BANDPASS AND GAIN ALIGNMENT

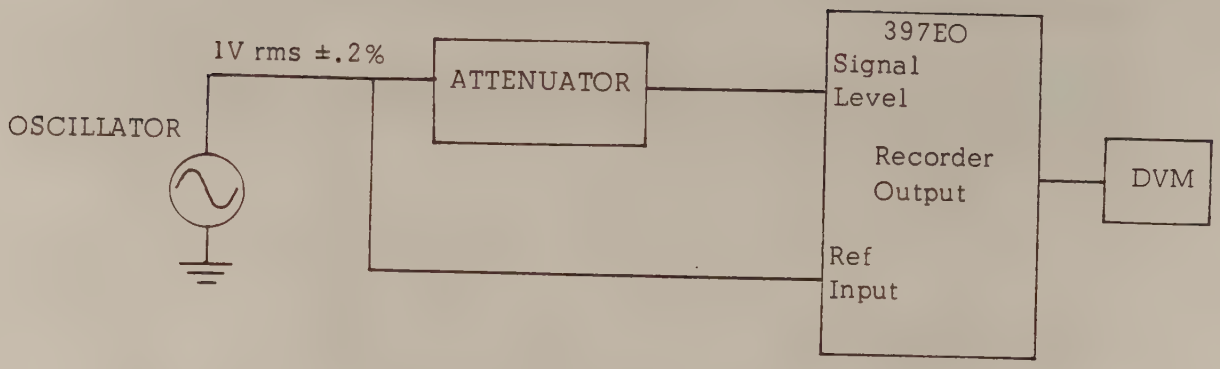

FIGURE 5.3

Set up the 397EO as in Figure 5.3.
Adjust the oscillator frequency to about 1 kHz and set the attenuator for 60 dB to make the signal input 1mV.
Set the Sensitivity switch for 1mV and the Time Constant switch for .25s.
Align the bandpass filter by adjusting A1-R86 for max reading on the DVM and adjusting A1-R84 for 10.00 VDC reading on the DVM. Repeat until no further improvement can be obtained.
Step the 10 dB step attenuator from 0 to 100 dB in 20 dB steps while stepping the sensitivity from 1V to 10μV.
Check that the DVM reads 10.0 ±.1V at each sensitivity position.
If necessary, readjust A1-R84 (adjusts gain at all sensitivity positions).

5.11 OUTPUT, ZERO SUPPRESS

Adjust the reference frequency to 1 kHz.
Set the Sensitivity switch to 1V with an open input connector.
Short A3-TP1 and A3-TP3 to A3-TP2.
Set Output switch to Normal.
Set Zero Suppress switches to 0% and OFF.
Set Normal/Ratio switch to Normal.
Verify that A1-TP15 is 0 ±2mV.
Monitor the recorder output with a DVM and adjust A1-R177 for 0 ±2mV.
Change Output switch to EXPAND and adjust R166 for 0 ±.5mV.
Rotate Zero Suppress switch from 0 to 100% and switch Output to Normal.
Adjust A1-R175 to give -9.995 to -10.005V on Recorder output.

5.12 METER CALIBRATION

Connect a reference to the lock-in and set the Sensitivity to 1V, not expanded.

Verify that the output reads 0 ±5mV and adjust R14 (R6) on A10 to give a zero reading on the internal DVM.
Turn the 397EO power off briefly and set the Analog meter zero adjustment screw for proper zero.
Turn power back on.
With the set up in Figure 5.3 set the Sensitivity to 1V and the attenuator to 0 dB. Jumper A3-TP1 and A3-TP3 to A3-TP2 and adjust A10-R14 (R6) for the same reading on the internal DVM as on the external DVM. Note that 100% equals 10.0V.
Disconnect jumpers.
Set the oscillator level control for a 10.00 ±.002V reading on the external DVM.
Then adjust A1-R180 for full scale deflection on the Analog meter.
Then adjust A10-R3(R7) for 100.0% on the internal DVM.
NOTE: Numbers in ( ) indicate adjustments on A10-DVM card - C32851

5.13 RATIOMETER - OPTION 02EO

5.13.1 ADJUSTMENT

Connect a shorting cap across the Ratiometer Y input on the rear panel.
Adjust Ratiometer pot R1 until the voltage on Ratiometer pad 12 (U1, pin 6) is 0 ±0.1mV.
Turn the Ratiometer normalization pot fully counterclockwise.
Adjust Ratiometer pot R4 until the voltage on U2 Pin 6 output is 0 ±0.5mV. This voltage may be measured at pin 3 on the rear panel pot.

5.13.2 ACCURACY CHECK

Accuracy may be checked by inserting appropriate signals. A convenient way of checking a ratio of 1/1 for various levels is as follows:

a. Move the Ratio Option electrically to AFTER the Zero Suppress, (see Section 5.13.3).
b. Connect a clip lead from Ratiometer Pad 7 (X input) to the Y input BNC on the rear panel.
c. Connect an oscillator to the reference and signal inputs on the 397EO and set the Normal/Option switch on the front panel to Normal. Go to unexpanded mode.
d. Adjust sensitivity for full scale output on front panel.
e. Set the Normal/Option switch to Option.
f. Adjust the Y level adjust pot on the rear panel for 100% ratio on the front panel.
g. Step the Zero Suppress from 0 to 90% and observe that the ratio output on the DVM stays within 2% of 100%. This verifies that the accuracy is within 2% from 1.0 to 10.0 volts input).
h. Increase the Zero Suppress using the variable control until the front panel reading error is 2%. (98 or 102%)
i. Throw the Output switch back to Normal from Option and go to EXPAND. Observe that the output is less than 10% of Full Scale. This verifies that the ratio error is less than 2% from 1% to 10% of full scale.

j. Return the Ratio Option to its original position electrically.

5.13.3 MOVING THE OPTION ELECTRICALLY

⚠ WARNING - Dangerous voltages may be present inside the lock-in. Refer servicing to qualified personnel. Always remove high voltage signal inputs and AC power while opening the unit.

When shipped from the factory the Ratio Option is located before the Zero Suppress function. Below are instructions to move the Option to after the Zero Suppress and back.

5.13.3.1 RATIO AFTER ZERO SUPPRESS

a. Unplug the lock-in and remove any input wires.
b. Remove the top cover.
c. Locate the A16 output block on A1 (see Figure 7.1 or Figure 5.5).
d. Remove the block and reinstall as shown in Figure 5.5.
e. Replace top cover.

5.13.3.2 RATIO BEFORE ZERO SUPPRESS

a. Unplug lock-in and remove input wires.
b. Remove top cover.
c. Locate A16 Output Block (see Figure 7.1)
d. Remove block and reinstall as shown in Figure 5.4.
e. Replace top cover.

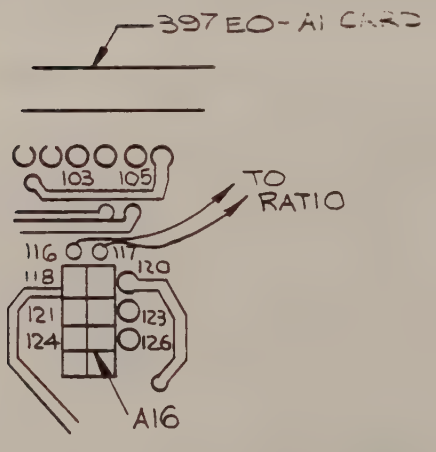

FIGURE 5.4
RATIO BEFORE
ZERO SUPPRESS

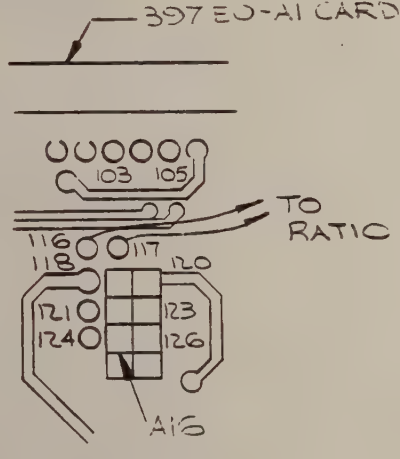

FIGURE 5.5
RATIO AFTER
ZERO SUPPRESS

5.14 LOG OPTION - OPTION 09EO

5.14.1 ALIGNMENT

a. Connect an oscillator to the reference and signal input connectors on the 397EO. Set the front panel Option switch to Normal.
b. Connect an external DVM to the front panel output BNC and monitor the voltage.
c. Adjust the oscillator and lock-in gain to give exactly 0.100 volts output on the DVM.
d. Switch the Option switch to Option position.
e. Adjust R1 on the Log Option for Zero ±1mV out from the front panel BNC.
f. Switch back to Normal from Option and adjust the lock-in for 10.00 volts output.
g. Go back to Option from Normal, and adjust R13 on the Log Option for +2.00 volts out.
h. In a similar way, check to see that a +1.0 volt lock-in output gives a +1.0 volt ±8mV log output.

NOTE: If the Log Option has been modified to give 2V/decade output, multiply all log outputs above by 2.

5.14.2 MODIFICATION FOR dB OUTPUT

The following change allows the user to view the log output directly in dB on the front panel:

a. Disconnect AC power and remove all signal wires to the lock-in.
b. Remove the top cover.
c. Locate the jumper between R8 and CR1 on the option board, and clip it out.
d. Align the Option per 5.14.1.
e. Replace the top cover.

SECTION 6

REPLACEABLE PARTS

6.1 INTRODUCTION

This section contains the information needed for ordering replacement parts.

6.2 REFERENCE DESIGNATIONS AND ABBREVIATIONS

Table 6.1 is a list of reference designations and abbreviations.

6.3 REPLACEABLE PARTS

Table 6.2 lists parts in alphabetical order of their reference designations with locations and descriptions for each part.

6.3.1 EXPLANATION OF LOCATION COLUMN

Each page of Table 6.2 has at the top of the page the description and the ITHACO Drawing Number for the parts listed.

The location code is broken down as follows:

LOCATION		
Sch	Asm	The first digit or (digits) is the page number of the schematic. The letter and digit following locate the part on that particular schematic.
3D9	C9	

The letter and number under the assembly column locate the part on the assembly drawing.

6.4 CODE LIST OF MANUFACTURERS

Table 6.3 is a Code List of Manufacturers. The manufacturer's code is given with each part. If a code number is missing, the part is a standard designation and is available from many manufacturers.

REFERENCE DESIGNATIONS

A	assembly subassembly, separable or repairable
AR	amplifier
AT	attenuator pad termination
B	blower motor synchro
BT	battery
C	capacitor
CB	circuit breaker
CP	adapter, connector coupling (aperture, loop or probe) junction (coaxial or waveguide)
CR	diode rectifier
DS	alarm indicator (excluding meter)
E	antenna arrester, lightning bimetallic strip cell, aluminum or electrolytic contact core, inductor core, memory core, transformer Hall effect device insulator loop antenna magnet, permanent part, miscellaneous electrical post, binding shield, electrical terminal (individual)
F	fuse
FL	filter
G	chopper, electronic generator
H	hardware
HR	heater lamp, infrared
HS	handset
HY	network, hybrid circuit
J	connector, receptacle, electrical disconnecting device jack receptacle (connector, stationary portion)
K	relay
L	coil (all not classified as transformers) inductor
M	clock counter, electrical meter oscillograph oscilloscope recorder, elapsed time register, message strain gage thermometer timer, electric
MK	microphone
MP	frame gyroscope interlock, mechanical mechanical part mounting (not electrical circuit, not a socket) part, miscellaneous mechanical (bearing, coupling, gear, shaft) part, structural reed, vibration tuning fork
MT	transducer transducer, mode
P	connector, plug, electrical disconnecting device (connector, plug)
	plug, electrical (connector, movable portion)
PS	power supply
Q	transistor
R	potentiometer resistor
RT	lamp, resistance resistor, current regulating resistor, thermal thermistor
RV	resistor, voltage sensitive varistor, symmetrical
S	switch thermostat
T	transformer
TB	strip, terminal terminal board
TC	thermocouple
TP	test point
U	integrated circuit package
V	cell, light-sensitive, photo-emissive electron tube
W	cable cable assembly (with connectors) wire
WT	tiepoint, wiring
X	fuseholder lampholder socket
Y	crystal unit, piezoelectric

ABBREVIATIONS

A	ampere
AC	alternating current
ALUM	aluminum
AMPL	amplifier
ASSY	assembly
BP	bandpass
CAL	calibration
CAR	carbon
CCW	counterclockwise
CER	ceramic
CKT	circuit
COMP	composition
CRT	cathode-ray tube
CW	clockwise
dB	decibel
DC	direct current
DET	detector
DVM	digital voltmeter
ELECT	electrolytic
ENCAP	encapsulated
EXT	external
F	farads
FET	field effect transistor
FREQ	frequency
FXD	fixed
GE	germanium
GL	glass
GND	ground
H	henries
HPF	high-pass filter
HR	hour
Hz	hertz
IF	intermediate frequency
INS	insulation(ed)
INT	internal
K	kilo = 1000
LED	light emitting diode
LIN	linear taper
LOG	logarithmic taper
LPF	low-pass filter
M	Millo 10^{-3}
MEG	meg 10^{6}
METFLM	metal film
MFR	manufacturer
MINAT	miniature
MOM	momentary
MTG	mounting
MYFLM	"mylar" film
N	nano (10^{-3})
N/C	normally closed
NE	neon
N/O	normally open
NPO	negative positive zero
NSR	not separately replaceable
OSC	oscillator
OP	operational
PC	printed circuit
PF	picofarads 10^{-12} farads
PIV	peak inverse volt voltage
P/P	part of
PPM	parts per million
POLY	polystyrene
POLYCARB	poly carbonate
POS	position(s)
POT	potentiometer
P-P	peak-to-peak
RC	resistor capacitor network
RECT	rectifier
REF	reference
RF	radio frequency
RMS	root-means-square
S-B	slow-blow
SCR	screw
SE	selenium
SEC	second
SECT	section(s)
SEMICON	semiconductor
SI	silicon
SIL	silver
SL	slide
SOL	solid
SPL	special
TA	tantalum
TGL	toggle
TOL	tolerance
TRIM	trimmer
μ	micro 10^{-6}
V	volt
VAR	variable
VDCW	dc working volts
VCO	voltage controlled oscillator
W/	with
W	watts
WW	wirewound
W/O	without

TABLE 6.1 LIST OF REFERENCE DESIGNATIONS AND ABBREVIATIONS

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
A1		D3	Asm, A1 Motherboard	D42035G1	31	D42035G1
A2		D6	Asm, A2 Motherboard	D42034G1	31	D42034G1
A3		C3	Asm, Vector Summer	C31912G1	31	C31912G1
A4		C3	Asm, Phase Sensitive Detector	C31903G1	31	C31903G1
A5		C3	Asm, Phase Sensitive Detector	C31903G1	31	C31903G1
A6		D3	Asm, Low Pass Amplifier	C31904G1	31	C31904G1
A7		D4	Asm, Low Pass Amplifier	C31904G1	31	C31904G1
A8		G4	Asm, Current Preamp	C32266G1	31	C32266G1
A9		G3	Asm, Voltage Preamp	C32247G1	31	C32247G1
A10		C5	Asm, DVM	C32271G1	31	C32271G1
A16		B4	Output Block	812122405	81	65843-002
R5		G5	Asm, Resistor Jumper	A12258G1	31	A12258G1
R6		G5	Asm, Resistor Jumper	A12258G1	31	A12258G1
R7		G5	Asm, Resistor Jumper	A12258G1	31	A12258G1
T1		B6	Transformer Asm	C31942G1	31	C31942G1
W1		B7	Power Supply Cord	816000101	6	17250
W2		A3	Cable, Ribbon	B22652G19	31	B22652G19
W3		A4	Cable, 15 Pin Single Row	A12201G1	31	A12201G1

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			CAPACITORS			
C1	1-B4	F9	1µF, 35V, 10%, Sol Ta	811504028	48	196D-105X9035HA1
C2	1-B4	F9	1µF, 35V, 10%, Sol Ta	811504028	48	196D-105X9035HA1
C3	1-B4	F9	.01µF, 500V, 20%, Cer	811570019	48	5GAS-S10
C4	1-C4	F9	.01µF, 500V, 20%, Cer	811570019	48	5GAS-S10
C5	1-A5	F8	.01µF, 500V, 20%, Cer	811570019	48	5GAS-S10
C6	1-B5	F8	.01µF, 500V, 20%, Cer	811570019	48	5GAS-S10
C7	1-B7	D8	.05µF, 100V, 20%, Cer	811570007	48	TG-S50
C8	1-B8	E8	47µf, 20V, 10%, Sol Ta	811504021	48	196D476X9020LA3
C9	1-B8	E8	.05µf, 100V, 20%, Cer	811570007	48	TG-S50
C10	1-B8	D9	.0033µF, 100V, 10%, Myflm	811551007	28	60F10AA332
C11	1-B9	E8	.05µF, 100V, 20%, Cer	811570007	48	TG-S50
C12	1-C7	D8	2200pF, 1%, 500V, Sil Mica	811581064	17	CD19FD222F03
C13	1-C8	E8	1000pF, 1%, 500V, Sil Mica	811581045	17	CD19FD102F03
C14	1-C8	E8	100pF, 1%, 500V, Sil Mica	811581050	17	CD15FD101F03
C15	1-C9	D9	150pF, 1000V, 20%, Cer	811572012	48	10TS-T15
C16	1-D7	D8	15µF, 20V, 10%, Sol Ta	811504020	48	196D156X9020KA1
C17	1-D7	D8	.05µF, 100V, 20%, Cer	811570007	48	TG-S50
C18	1-D8	D8	.05µF, 100V, 20%, Cer	811570007	48	TG-S50
C19	1-C9	F9	.068µF, 200V, 10%, Mylar	811553005	22	W210B1C-683K
C20	1-D9	E9	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C21	1-D9	E9	.05µF, 100V, 20%, Cer	811570007	48	TG-S50
C22	1-F2	B9	.05µF, 100V, 20%, Cer	811570007	48	TG-S50
C23	1-F3	B9	5.5-18pF, Var	811590008	25	538-002A5.5-18
C24	1-G1	C10	15µF, 20V, 10%, Sol Ta	811504020	48	196D156X9020KA1
C25	1-G2	C10	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C26	1-H2	C9	.05µF, 100V, 20%, Cer	811570007	48	TG-S50
C27	1-H2	C10	15pF, 1000V, 20%, Cer	811572024	48	10TS-Q15
C28	1-G3	C9	.05µF, 100V, 20%, Cer	811570007	48	TG-S50
C29	1-HB	C9	5.5-18pF, Var	811590008	25	538-002A5.5-18
C30	1-G4	C10	47µF, 20V, 10%, Sol Ta	811504021	48	196D476X9020LA3
C31	1-H4	B10	47µF, 20V, 10%, Sol Ta	811504021	48	196D476X9020LA3
C32	1-E7	C7	.05µF, 100V, 20%, Cer	811570007	48	TG-S50
C33	1-G7	C7	.05µF, 100V, 20%, Cer	811570007	48	TG-S50
C34	1-E7	D7	.047µF, 100V, 10%, Myflm	811551012	28	61F19AA473
C35	1-E8	D7	1000pF, 500V, 1%, Sol Mica	811581045	17	CD19FD102F03

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			CAPACITORS (Continued)			
C36	1-E8	D7	.05µF, 100V, 20%, Cer	811570007	48	TG-S50
C37	1-F8	D7	.05µF, 100V, 20%, Cer	811570007	48	TG-S50
C38	1-E9	E7	1000pF, 1%, 500V, Sil Mica	811581045	17	CD19FD102F03
C39	1-E10	E7	.05µF, 100V, 20%, Cer	811570007	48	TG-S50
C40	1-F10	E7	.05µF, 100V, 20%, Cer	811570007	48	TG-S50
C41	1-F9	F7	.05µF, 100V, 20%, Cer	811570007	48	TG-S50
C42	1-G9	F7	.05µF, 100V, 20%, Cer	811570007	48	TG-S50
C43	1-G8	F7	.01µF, 500V, 20%, Cer	811570019	48	5GAS-S10
C44	4-E4	F5	5µF, 1%, 200V, Polycarb	811540049	22	W625B1C505F
C45	4-F4	E6	.05µF, 1%, 200V, Polycarb	811540051	22	W625B1C504F
C46	4-G4	E5	.05µF, 1%, 200V, Polycarb	811540052	22	W625B1C503F
C47	4-E7	F6	5µF, 1%, 200V, Polycarb	811540049	22	W625B1C505F
C48	4-F7	E6	0.5µF, 1%, 200V, Polycarb	811540051	22	W625B1C504F
C49	4-G7	E5	.05µF, 1%, 200V, Polycarb	811540052	22	W625B1C503F
C50	6-E4	C5	5µF, 1%, 200V, Polycarb	811540049	22	W625B1C505F
C51	6-F4	C6	0.5µF, 1%, 200V, Polycarb	811540051	22	W625B1C504F
C52	6-G4	B5	0.05µF, 1%, 200V, Polycarb	811540052	22	W625B1C503F
C53	6-E7	C6	5µF, 1%, 200V, Polycarb	811540049	22	W625B1C505F
C54	6-F7	B6	0.5µF, 1%, 200V, Polycarb	811540051	22	W625B1C504F
C55	6-G7	B5	0.05µF, 1%, 200V, Polycarb	811540052	22	W625B1C503F
C56	8-D1	F1	.1µF, 200V, 10%, Polycarb	811540065	22	626B1C104K
C57	8-D1	F1	22pF, 1000V, 20%, Cer	811572003	48	10TS-Q22
C58	8-D2	E1	15µF, 20V, 10%, Sol Ta	811504020	48	196D156X9020KA1
C59	8-D2	E1	.05µF, 100V, 20%, Cer	811570007	48	TG-S50
C60	8-D2	E1	15µF, 20V, 10%, Sol Ta	811504020	48	196D156X9020KA1
C61	8-E2	E1	.05µF, 100V, 20%, Cer	811570007	48	TG-S50
C62	8-E2	E1	15µF, 20V, 10%, Sol Ta	811504020	48	196D156X9020KA1
C63	12-E1	D2	2.2µF, 25V, 10%, Sol Ta	811504023	48	196D225X9025HA1
C64	12-F2	E2	2.2µF, 25V, 10%, Sol Ta	811504023	48	196D225X9025HA1
C65	10-B4	C3	.01µF, 500V, 20%, Cer	811570019	48	5GAS-S10
C66	10-C4	C3	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C67	10-C4	D3	.01µF, 500V, 20%, Cer	811570019	48	5GAS-S10
C68	10-D4	E3	.01µF, 500V, 20%, Cer	811570019	48	5GAS-S10
C69	10-E4	E3	.01µF, 500V, 20%, Cer	811570019	48	5GAS-S10
C70	10-E4	E3	1µF, 35V, 10%, Sol Ta	811504028	48	196D105X9035HA1

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			CAPACITORS (Continued)			
C71	10-B5	E2	.01μF, 500V, 20%, Cer	811570019	48	5GAS-S10
C72	10-B5	E2	.01μF, 500V, 20%, Cer	811570019	48	5GAS-S10
C73	10-B5	E2	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C74	10-D5	E3	.01μF, 500V, 20%, Cer	811570019	48	5GAS-S10
C75	10-D5	D3	.01μF, 500V, 20%, Cer	811570019	48	5GAS-S10
C76	1-A3	D10	15μF, 20V, 10%, Sol Ta	811504020	48	196D156X9020KA1
C77	1-A4	D10	15μF, 20V, 10%, Sol Ta	811504020	48	196D156X9020KA1
C78	1-C4	F9	100pF, 500V, 5%, Sil Mica	811581008	17	CD15FD101J03
			DIODES			
CR1	1-B3	F10	IN4005	818100007		IN4005
CR2	1-B3	F10	IN4005	818100007		IN4005
CR3	1-C3	F10	IN4148	818100003		IN4148
CR4	1-D3	F10	IN4148	818100003		IN4148
CR5	1-C4	E8	IN4005	818100007		IN4005
CR6	1-A5	F8	IN4148	818100003		IN4148
CR7	1-A5	F8	IN4148	818100003		IN4148
CR8	1-F3	B9	2800, 70V	818100012	83	5082-2800
CR9	1-F4	B9	IN4148	818100003		IN4148
CR10	1-H2	C10	IN4148	818100003		IN4148
CR11	1-G3	C9	2800, 70V	818100012	83	5082-2800
CR12	1-H4	C9	IN4148	818100003		IN4148
CR13	1-G5	B10	IN5242B, 12V, 5%	818150043		IN5242B
CR14	1-H5	B10	IN5242B, 12V, 5%	818150043		IN5242B
CR15	1-G8	F7	IN4148	818100003		IN4148
CR16	8-D1	F1	IN4148	818100003		IN4148
CR17	8-D1	F1	IN4148	81810003		IN4148
CR18	8-E3	E1	IN4148	81810003		IN4148
CR19	8-G6	F2	IN4148	81810003		IN4148
CR20	12-F2	E2	IN4148	81810003		IN4148

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			DIODES (continued)			
CR21	12-F3	F2	IN4148	818100003		IN4148
CR22	10-E2	D2	IN4148	818100003		IN4148
CR23	10-E2	D2	IN4148	818100003		IN4148
CR26	10-E3	D2	IN4148	818100003		IN4148
CR27	10-E3	D2	IN4148	818100003		IN4148
CR28	10-F6	F2	IN4148	818100003		IN4148
L1	1-C8	E8	Choke - Ferrite Bead	811800014	51	1568
L2	1-F4	B9	Choke - 100μH	811800022	20	1537-76
L3	1-G4	C9	Choke - 100μH	811800022	20	1537-76
L4	1-G5	B10	Choke - 10μH	811800024	20	1537-36
L5	1-H5	B10	Choke - 10μH	811800024	20	1537-36
			TRANSISTORS			
Q1	1-C3	F9	2N3904	818203904		2N3904
Q2	1-C3	F10	2N3906	818203906		2N3906
Q3	1-A5	G8	2N3904	818203904		2N3904
Q4	1-A5	G8	2N3906	818203906		2N3906
Q5	1-C6	D8	A96013P10	A86013P10	31	A86013P10
Q6	1-B7	D8	2N3906	818203906		2N3906
Q7	1-C8	D9	A86013P10	A86013P10	31	A86013P10
Q8	1-C9	D9	2N3906	818203906		2N3906
Q9	1-C9	D9	2N2219	818202219		2N2219
Q10	1-C7	D8	2N3904	818203904		2N3904

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			TRANSISTORS (continued)			
Q11	1-D8	D8	2N3904	818203904		2N3904
Q12	1-C8	D8	2N2219	818202219		2N2219
Q13	1-E2	B8	SD214	818700035	71	SD-214
Q14	1-E2	B8	SD214	818700035	71	SD-214
Q15	1-E3	C8	SD214	818700035	71	SD-214
Q16	1-E3	C8	SD214	818700035	71	SD-214
Q17	1-F3	B9	MPS2369	818700033	35	MPS2369
Q18	1-F3	B9	MPS2369	818700033	35	MPS2369
Q19	1-F3	B9	2N3904	818203904		2N3904
Q20	1-F4	B9	2N3904	818203904		2N3904
Q21	1-G2	C9	MPS2369	818700033	35	MPS2369
Q22	1-G3	C9	MPS2369	818700033	35	MPS2369
Q23	1-G3	C9	2N3904	818203904		2N3904
Q24	1-G4	C9	2N3904	818203904		2N3904
Q25	1-E6	C7	2N3906	818203906		2N3906
Q26	1-E6	C7	2N3906	818203906		2N3906
Q27	1-E6	C7	2N3906	818203906		2N3906
Q28	1-E1	C7	2N3906	818203906		2N3906
Q29	1-E5	B7	TIS75	818700009	55	TIS-75
Q30	1-E6	B7	TIS75	818700009	55	TIS-75
Q31	1-E5	B7	2N3904	818203904		2N3904
Q32	1-E6	B7	2N3904	818203904		2N3904
Q33	1-G7	C7	2N3904	818203904		2N3904
Q34	1-G7	C7	2N3904	818203904		2N3904
Q35	1-G7	C7	2N3904	818203904		2N3904
Q36	1-G8	F7	2N3906	818203906		2N3906
Q37	8-D2	F1	TIS75	818700009	55	TIS-75
Q38	8-G7	F2	2N3904	818203904		2N3904
Q39	12-E1	D2	2N3906	818203906		2N3906
Q40	12-F3	F2	2N3904	818203904		2N3904
Q41	10-E2	D2	2N3904	818203904		2N3904
Q42	10-F2	D2	2N3906	818203906		2N3906
Q43	1-A4	E10	TIS97	818700046	55	TIS-97
Q44	1-A4	D10	2N4250	818204250		2N4250

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			RESISTORS All resistors not otherwise designated are 1/4W, 5%, Comp * 1/8W, 1%, Metflm ** 1/8W, 0.1%, Metflm ***1/10W, 1%, Temp Stable, Metflm			
R1	1-B3	E10	68 ohm, 1/2W, FR, 5%	817002027	99	5043CX68R00JBV
R2	1-C3	F9	10K	817007103		RC07
R4	1-A4	D10	5.6K	817007562		RC07
R5	1-A4	D10	5.6K	817007562		RC07
R6	1-B4	G9	3.3M	817007335		RC07
R7	1-C4	E8	1.000K, **	817261042	63	ACI REA 1/8, 1.0K C-1
R8	1-C4	E8	1.2K, 1/2W, 5%	817020122		RC20
R9	1-C4	E8	1.2K, 1/2W, 5%	817020122		RC20
R10	1-C4	F9	9.003K, **	817261114	63	ACI RE 1/4 C-1 9.003K
R12	1-A5	F8	10K	817007103		RC07
R13	1-B5	F8	10.00K, **	817261048	63	ACI REA 1/8, 10K C-1
R14	1-B5	F8	3.162K, **	817261147	63	ACI RE 1/4,C-1 3.162K
R15	1-B5	F8	1.000K, **	817261042	63	ACI REA 1/8,1.0K C-1
R16	1-C5	F8	316.2 ohm **	817261002	63	ACI REA 1/8, 316.2 C-1
R17	1-C5	F8	100.0 ohm, **	817261032	63	ACI REA 1/8, 100.0Ω ,C1
R18	1-C5	F8	46.24 ohm, **	817261149	42	PME55
R19	1-B6	C8	1K	817007102		RC07
R20	1-B6	D8	220 ohm	817007221		RC07
R21	1-B6	D8	470 ohm	817007471		RC07
R22	1-B7	D8	6.81K, **	817211681		RN60D
R23	1-B7	D8	1.96K, *	817211196		RN60D
R24	1-B7	D8	18K	817007183		RC07
R25	1-B7	D8	21.5K, *	817212215		RN60D
R26	1-B7	E8	31.6K, *	817212316		RN60D
R27	1-B8	E8	2.15K, *	817211215		RN60D
R28	1-B8	C9	220 ohm	817007221		RC07
R29	1-B8	D9	470 ohm	817007471		RC07
R30	1-B8	D9	18 ohm	817007180		RC07

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			RESISTORS (continued)			
R31	1-B9	E8	56 ohm	817007560		RC07
R32	1-C9	D9	270 ohm	817007271		RC07
R33	1-C9	D9	10K	817007103		RC07
R34	1-C9	C8	47 ohm	817007470		RC07
R35	1-C7	E8	2.2K	817007222		RC07
R36	1-D7	D8	100 ohm	817007101		RC07
R37	1-D7	E8	34.8K, *	817212348		RN60D
R38	1-C8	D8	4.7K	817007472		RC07
R39	1-D8	D8	4.7K	817007472		RC07
R40	1-C8	D8	56 ohm	817007560		RC07
R41	1-D8	C8	56 ohm	817007560		RC07
R42	1-C9	E9	470K	817007474		RC07
R43	1-C9	C9	10K	817007103		RC07
R44	1-D9	E9	470K	817007474		RC07
R45	1-D10	E9	560 ohm	817007561		RC07
R46	1-D10	E9	1M	817007105		RC07
R47	1-D10	E9	50K, POT	817803503	7	3386P-1-503
R48	1-D2	B8	22M	817007226		RC07
R49	1-E2	B8	22M	817007226		RC07
R50	1-D2	B8	22M	817007226		RC07
R51	1-E2	B8	22M	817007226		RC07
R52	1-D3	C8	22M	817007226		RC07
R53	1-E3	C8	22M	817007226		RC07
R54	1-D4	C8	22M	817007226		RC07
R55	1-E4	C8	22M	817007226		RC07
R56	1-F2	B10	10K	817007103		RC07
R57	1-F3	B9	10K	817007103		RC07
R58	1-F3	B9	10K	817007103		RC07
R59	1-F4	B9	3.3K	817007332		RC07
R60	10F2	B10	330 ohm	817007331		RC07
R61	1-G2	C10	2.2K	817007222		RC07
R62	1-G2	C10	330 ohm	817007331		RC07
R63	1-G3	C9	10K	817007103		RC07
R64	1-G3	C9	3.3K	817007332		RC07
R65	1-G5	B10	100 ohm, 1/2W, 5%	817020101		RC20

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			RESISTORS (continued)			
R66	1-H4	B10	100 ohm, 1/2W, 5%	817020101		RC20
R67	1-F5	B7	220 ohm	807007221		RC07
R68	1-F5	B7	220 ohm	817007221		RC07
R69	1-E5	C7	681 ohm, *	817210681		RN60D
R70	1-E6	C7	681 ohm, *	817210681		RN60D
R71	1-E6	C7	681 ohm, *	817210681		RN60D
R72	1-E7	C7	681 ohm, *	817210681		RN60D
R73	1-F7	C7	4.22K, *	817211422		RN60D
R74	1-F6	B7	3.83K, *	817211383		RN60D
R75	1-F6	C7	22K	817007223		RC07
R76	1-G5	B7	681 ohm, *	817210681		RN60D
R77	1-G6	B7	681 ohm, *	817210681		RN60D
R78	1-G6	C7	18K	817007183		RC07
R79	1-G6	C7	4.7K	817007472		RC07
R80	1-G6	C7	681 ohm, *	817210681		RN60D
R81	1-G7	C7	681 ohm, *	817210681		RN60D
R82	1-F8	D7	8.25K, *	817211825		RN60D
R83	1-E8	D7	75.0K, *	817212750		RN60D
R84	1-E8	E7	20K, POT	817803203	7	3386P-1-203
R85	1-E9	D7	1K	817007102		RC07
R86	1-E9	E7	1K, POT	817803102	7	3386P-1-102
R87	1-E9	E7	2.87K, *	817211287		RN60D
R88	1-E10	E7	1K	817007102		RC07
R89	1-F8	F7	1K	817007102		RC07
R90	1-F9	F7	5.11K, *	817211511		RN60D
R91	1-G9	E7	5.11K, *	817211511		RN60D
R92	1-G8	F7	18K	817007183		RC07
R93	1-G8	F7	22K	817007223		RC07
R94	4-E1	F5	11.25K, **	817261113	63	ACI RE 1/4C-1 11.25K
R95	4-D3	F5	56.27K, **	817261105	63	ACI RE 1/4 C-1 56.27K
R96	4-D2	F7	33M	817000005	3	CB3365
R97	4-E2	F7	2.251M, **	817261089	63	ACI AME-60 2.251M
R98	4-E2	F7	357.3K, **	817261097		ACI RE 1/4 C-1 357.3K
R99	4-F2	E5	75.0K, *	817212750		RN60D
R100	4-F2	E5	2.7M	817007275		RC07

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			RESISTORS (continued)			
R101	4-F2	E5	18.01K, **	817261110	63	ACI RE 1/4 C-1 18.01K
R102	4-F2	E5	470 ohm	817007471		RC07
R103	4-E5	E5	75.0K, *	817212750		RN60D
R104	4-E5	E5	357.3K, **	817261097	63	ACI RE 1/4 C-1 357.3K
R105	4-E5	E5	68.1K,*	817212681		RN60D
R106	4-E5	E5	6.19K, *	817211619		RN60D
R107	4-F5	E5	17.8K, *	817212178		RN60D
R109	4-F5	E5	47 ohm	817007470		RC07
R110	4-C5	F5	1.646K, **	817261012	63	REA 1/8, 1.646K C1
R112	4-C5	F5	31.62K, **	817261126	63	RE 1/4 C-1 31.62K
R113	6-E1	D5	11.25K, **	817261113	63	ACI RE 1/4 C-1 11.25
R114	6-D3	C5	56.27K, **	817261105	63	ACI RE 1/4 C-1 56.27K
R115	6-E2	D5	33M	817000005	3	CB3365
R116	6-E2	D5	2.251M, **	817261089	63	ACI AME-60 2.251M
R117	6-E2	D5	357.3K, **	817261097	63	ACI RE 1/4 C-1 357.3K
R118	6-F2	C5	75.0K, *	817212750		RN60D
R119	6-F2	C5	2.7M	817007275		RC07
R120	6-F2	C5	18.01K, **	817261110	63	ACI RE 1/4 C-1 18.01K
R121	6-F2	C5	470 ohm	817007471		RC07
R122	6-D5	C5	75.0K, *	817212750		RN60D
R123	6-E5	B5	357.3K, **	817261097	63	ACI RE 1/4 C-1 357.3K
R124	6-E5	C5	68.1K, *	817212681		RN60D
R125	6-E5	C5	6.19K, *	817211619		RN60D
R126	6-F5	B5	17.8K, *	817212178		RN60D
R128	6-F5	B5	47 ohm	817007470		RC07
R129	6-C5	C5	1.646K, **	817261012		REA 1/8, 1.646K C1
R131	6-C5	C5	31.62K, **	817261126	63	RE 1/4 C-1 31.62K
R132	7-B1	B3	500 ohm, POT	817803501	7	3386P-1-501
R133	7-E1	F4	261 ohm,*	817210261		RN60D
R134	8-C1	F1	10K	817007103		RC07
R135	8-D1	F1	10M	817007106		RC07

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			RESISTORS (continued)			
R136	8-D1	F1	470 ohm	817007471		RC07
R137	8-D2	D1	10 ohm	807007100		RC07
R138	8-D2	E1	33K	817007333		RC07
R139	8-E2	F1	2.2K	817007222		RC07
R140	8-E2	E1	33K	817007333		RC07
R141	8-E2	E1	6.8M	817007685		RC07
R142	8-E2	E1	10 ohm	817007100		RC07
R143	8-D3	D1	10K	817007103		RC07
R144	8-G6	F2	10K	817007103		RC07
R145	8-G7	F2	2.2K, 1W, 5%	817032222		RC32
R146	12-E2	D2	34.8K, *	817212348		RN60D
R147	12-E1	D2	220K	817007224		RC07
R148	12-E1	E2	34.8K, *	817212348		RN60D
R149	12-F2	E2	1M	817007105		RC07
R150	12-F2	E2	16.2K, *	817212162		RN60D
R151	12-G2	E2	6.81K, *	817211681		RN60D
R152	12-G3	E1	560K	817007564		RC07
R153	12-F3	F2	10K	817007103		RC07
R154	12-F4	F2	2.2K, 1W, 5%	817032222		RC32
R155	12-E4	F1	560 ohm, 1/2W, 5%	817020561		RC20
R156	10-E2	D2	56.2K, *	817212562		RN60D
R157	10-F2	C2	42.2K, *	817212422		RN60D
R160	10-E3	D2	56.2K, *	817212562		RN60D
R161	10-F3	D2	42.2K, *	817212422		RN60D
R162	10-C3	D3	4.7K	817007472		RC07
R163	10-C4	C3	10.0K, *	817212100		RN60D
R164	10-E4	E3	1K	817007102		RC07
R165	10-E6	F3	680 ohm, 1/2W, 5%	817020681		RC20
R166	10-C4	D2	100K, POT	817803104	7	3386P-1-104
R167	10-C5	E2	316.2, **	817261002	63	ACI REA 1/8, 316.2ΩC1
R168	10-C4	E2	330K	817007334		RC07
R169	10-C5	E2	683.8, **	817261004	63	ACI REA 1/8, 686.6Ω C1
R170	10-C5	E2	9.003K, **	817261114	63	ACI RE 1/4 C-1 9.003K

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			RESISTORS (continued)			
R171	10-D4	E3	11.0K, *	817212110		RN60D
R172	10-D4	E3	46.4K, *	817212464		RN60D
R173	10-E5	D3	7.50K *	817211750		RN60D
R174	10-E5	D3	10.0K, *	817212100		RN60D
R175	10-D6	F3	5K, POT	817803502	7	3386P-1-502
R176	10-E6	F3	6.8K	817007682		RC07
R177	10-E6	F3	10K, POT	817803103	7	3386P-1-103
R178	10-E6	F3	10 ohm	817007100		RC07
R179	10-F6	F2	5.62K, *	817211562		RN60D
R180	10-F6	F2	1K, POT	817803102	7	3386P-1-102
R181	10-F6	F2	3.83K, *	817211383		RN60D
R182	10-G6	F2	1K, *	817211100		RN60D
R183	10-F6	F2	1K, *	817211100		RN60D
R184	3-D3	B3	50K, POT	817805503	7	3299W-1-503
R185	5-D3	C3	50K, POT	817805503		3299W-1-503
R186	1-C10	B8	1K	817007102		RC07
R190	1-D1	F10	1K, *	817211100		RN60D
R191	1-A3	E10	1K	817007102		RC07
R192	1-A4	E10	1K	817007102		RC07
R193	10-C3	C3	100K	817007104		RC07
U1	1-B4	F9	LF356	816400063		LF356
U2	1-B5	F8	LF356	816400063		LF356
U3	1-D9	E9	LM308	816400003		LM308
U4	1-E8	D7	LM318	816400037		LM318
U5	1-F9	E7	LM318	816400037		LM318
U6	1-G9	F7	LM318	816400037		LM318
U7	8-D2	E1	LM311H	816400026		LM311H
U8	12-F3	E2	LM301A	A86050P4	31	A86050P4
U9	10-C4	C3	LM301A	A86050P4	31	A86050P4
U10	10-D5	D3	LF356	816400063		LF356
U11	10-E4	E3	LF356	816400063		LF356
U12	10-C5	E2	LM301A	A86050P4	31	A86050P4

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			CAPACITORS			
C1	9-B2	C10	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C2	9-B2	C10	.0022μF, 100V, 10%, Myflm	811551008	28	61F10AA222
C3	9-B2	C10	.0022μF, 100V, 10%, Myflm	811551008	28	61F10AA222
C4	9-A2	B8	.01μF, 500V, 20%, Cer	811570019	48	5GAS-S10
C5	9-D1	B8	1μF, 35V, 10%, Sol Ta	811504028	48	196D-105X9035HA1
C6	9-B4	D9	10pF, 1000V, 20%, Cer	811572001	48	10TS-Q10
C7	9-B5	D9	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C8	9-B6	E10	10pF, 1000V, 20%, Cer	811572001	48	10TS-Q10
C9	9-C5	D9	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C10	9-C5	E9	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C11	9-B7	E10	33μF, 10V, 10%, Sol Ta	811504043	48	196D-336X9010KA1
C12	9-B7	E10	22μF, 25V, 10%, Sol Ta	811504023	48	196D-225X9025HA1
C13	9-C8	F10	10pF, 1000V, 20%, Cer	811572001	48	10TS-Q10
C14	9-D2	E5	1000pF, 500V, 1%, Sil Mica	811581045	17	CD19FD102F03
C15	9-E1	E5	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C16	9-E2	E5	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C17	9-E2	E5	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C18	9-E3	F5	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C19	9-E2	F5	1000pF, 500V, 1%, Sil Mica	811581045	17	CD19FD102F03
C20	8-E5	D7	.01μF, 500V, 20%, Cer	811570019	48	5GAS-S10
C21	9-F4	F5	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C22	9-G1	F4	15μF, 20V, 10%, Sol Ta	811504020	48	196D-156X9020KA1
C23	9-G2	F4	15μF, 20V, 10%, Sol Ta	811504020	48	196D-156X9020KA1
C24	9-F4	F7	.01μF, 100V, 10%, Myflm	811551020	28	61F10AA103
C25	9-D6	E8	2.2μF, 25V, 10%, Sol Ta	811504023	48	196D-225X9025HA1
C26	9-D6	E9	2.2μF, 25V, 10%, Sol Ta	811504023	48	196D-225X9025HA1
C27	9-F5	E7	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C28	9-F5	E7	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C29	9-G5	E6	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C30	9-G5	E6	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C31	9-G6	F6	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C32	9-G6	F7	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C33	9-F6	F7	.0022μF, 100V, 10%, Myflm	811551008	28	61F10AA222
C34	9-F6	F6	15μF, 20V, 10%, Sol Ta	811504020	48	196D-156X9020KA1
C35	9-G7	F7	15μF, 20V, 10%, Sol Ta	811504020	48	196D-156X9020KA1

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			CAPACITORS (continued)			
C36	9-E8	E8	100pF, 500V, 1%, Sil Mica	811581045	17	CD19FD102F03
C37	9-D8	E8	.1μF, 100V, 1%, Polycarb	811540042	22	W625B1B104F
C38	9-E9	E7	.01μF, 400V, 1%, Polycarb	811540053	22	W625B1E103F
C39	8-C3	C7	.0022μF, 100V, 10%, Myflm	811551008	28	61F10AA222
C41	8-B4	B7	.0022μF, 100V, 10%, Myflm	811551017	28	61F15AA222
C42	8-E5	C8	.0022μF, 100V, 10%, Myflm	811551017	28	61F15AA222
C44	8-E7	C8	.33μF, 200V, 10%, Mylar	811553009	22	W230B1C-334K
C45	8-F9	C8	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C46	8-D7	D8	10μF, 200V, 10%, Mylar	811553015	22	W230B1C-106K
C47	8-C7	E8	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C48	8-B7	E8	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C49	8-F2	D6	15μF, 20V, 10%, Sol Ta	811504020	48	196D-156X9020KA1
C50	8-G1	D6	15μF, 20V, 10%, Sol Ta	811504020	48	196D-156X9020KA1
C51	8-G2	D6	15μF, 20V, 10%, Sol Ta	811504020	48	196D-156X9020KA1
C52	8-F2	D5	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C53	8-G2	D6	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C54	8-G2	D6	15μF, 20V, 10%, Sol Ta	811504020	48	196D-156X9020KA1
C55	8-H3	C6	680pF, 1000V, 20%, Cer	811572017	48	5GA-T68
C56	8-F4	C5	470pF, 1000V, 20%, Cer	811572015	48	10TS-T47
C57	8-C4	D6	.1μF, 200V, 10%, Polycarb	811540065	22	626B1C104K
C58	8-D9	B8	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C59	12-B4	D3	2400μF, 50V, Alum Foil	811530031	48	TG-S50
C60	12-C4	D2	2400μF, 50V, Alum Foil	811530031	28	86F564
C61	12-C5	C4	4.7μF, 10V, 10%, Sol Ta	811504038	48	196D-475X9010HA1
C62	12-C5	C4	1000pF, 1000V, 20%, Cer	811572019	48	5GA-D10
C63	12-B7	E4	.01μF, 500V, 20%, Cer	811570019	48	5GAS-S10
C64	12-C7	D4	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C65	12-B9	D5	47μF, 20V, 10%, Sol Ta	811504021	48	196D-476X9020LA3
C66	12-C9	D5	47μF, 20V, 10%, Sol Ta	811504021	48	196D-476X9020LA3
C67	12-F6	B5	10μF, 20V, 10%, Sol Ta	811504040	48	196D-106X9020JA1
C68	9-E7	F8	1000pF, 1000V, 20%, Cer	811572019	48	5GA-D10
C69	9-F5	F6	5pF, 500V, ±.5pF, Sil Mica	811581038	17	CD15CD050B03
C70	9-G5	F6	100pf,1000V, 20%, Cer	811572011	48	10TS-T10
C71	9-E5	E7	5pF, 500V, ±.5pF, Sil Mica	811581038	17	CD15CD050D03
C72	9-G5	F6	VAR, Selected			
C73	12-B4	F2	250μF, 50V, Alum Foil	811530019	17	BR-250-50
C74	9-C8	F10	.01μF, 500V, 20%, Cer	811570019	48	5GAS-S10
C75	9-B8	F10	.01μF, 500V, 20%, Cer	811570019	48	5GAS-S10

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			DIODES			
CR1	9-D2	B8	IN4148	818100003		IN4148
CR2	9-C4	D10	IN4148	818100003		IN4148
CR3	9-C5	D10	IN4148	818100003		IN4148
CR4	9-C5	E9	IN4148	818100003		IN4148
CR5	9-C6	E9	IN4148	818100003		IN4148
CR6	9-C7	E9	IN4148	818100003		IN4148
CR7	9-B8	F10	IN4148	818100003		IN4148
CR8	9-F2	E5	IN4148	818100003		IN4148
CR9	9-F2	E5	IN4148	818100003		IN4148
CR13	8-C4	C6	IN4148	818100003		IN4148
CR14	8-D5	B7	IN4148	818100003		IN4148
CR15	8-C7	D8	IN4148	818100003		IN4148
CR16	8-C7	E8	IN4148	818100003		IN4148
CR17	8-B7	D8	IN4148	818100003		IN4148
CR18	8-A7	E8	IN4148	818100003		IN4148
CR19	8-G3	D6	IN4148	818100003		IN4148
CR20	8-D9	B8	IN4005	818100007		IN4005
CR21	12-B4	D3	IN4005	818100007		IN4005
CR22	12-B4	D3	IN4005	818100007		IN4005
CR23	12-D4	D3	IN4005	818100007		IN4005
CR24	12-D4	D3	IN4005	818100007		IN4005
CR25	12-B6	C4	IN4005	818100007		IN4005
CR26	12-E8	C5	IN4005	818100007		IN4005
CR27	12-B9	C5	IN4005	818100007		IN4005
CR28	12-D9	D4	IN4005	818100007		IN4005
CR29	12-B8	C5	IN4148	818100003		IN4148
CR30	8-B6	D8	A86003P1, Low Leakage	A86003P1	31	A86003P1
CR31	8-C6	D8	A86003P1, Low Leakage	A86003P1	31	A86003P1
CR32	8-E5	D6	A86003P1, Low Leakage	A86003P1	31	A86003P1
CR33	8-E5	D6	A86003P1, Low Leakage	A86003P1	31	A86003P1
CR34	12-B4	E2	IN4005	818100007		IN4005
CR35	12-B4	E2	IN4005	818100007		IN4005
CR36	12-E9	B8	IN4005	818100007		IN4005
CR37	12-E9	B8	IN4005	818100007		IN4005

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
K1	8-E6	C8	Relay, 4PDT, 24V	814500008	92	CR4DDCA-24VDN
L1	9-B8	F10	Choke 100μH	811800022	20	1537-76
			TRANSISTORS			
Q1	9-B1	C10	2N3906	818203906		2N3906
Q2	9-B2	C10	2N3904	818203904		2N3904
Q3	9-B2	C9	MPS2369	818700033	35	MPS2369
Q4	9-C2	C9	2N3904	818203904		2N3904
Q5	9-B3	D9	MPS2369	818700033	35	MPS2369
Q6	9-B3	D10	2N3904	818203904		2N3904
Q7	9-B3	D10	2N3906	818203906		2N3906
Q8	9-B4	E10	MPS2369	818700033	35	MPS2369
Q9	9-B5	E9	MPS2369	818700033	35	MPS2369
Q10	9-B6	E9	2N3906	818203906		2N3906
Q11	9-C7	F9	MPS2369	818700033	35	MPS2369
Q12	9-C7	F9	MPS2369	818700033	35	MPS2369
Q13	9-C7	F9	2N3904	818203904		2N3904
Q14	9-D4	E8	2N3904	818203904		2N3904
Q15	9-D5	E9	2N3904	818203904		2N3904
Q16	9-D6	F8	2N4351	818204351		2N4351
Q17	9-D6	F9	2N4352	818204352		2N4352
Q18	8-B4	C6	2N3904	818203904		2N3904
Q19	8-B3	C7	2N3904	818203904		2N3904
Q20	8-B5	C7	2N3904	818203904		2N3904
Q21	8-E5	C8	A86039P18	A86039P18	31	A86039P18
Q22	8-D3	D5	2N3904	818203904		2N3904
Q23	8-G3	D5	2N3904	818203904		2N3904
Q24	12-D7	C5	2N3904	818203904		2N3904
Q25	12-C8	C4	2N3906	818203906		2N3906
Q26	8-F6	C9	2N3904	818203904		2N3904
Q27	8-D4	D6	2N3904	818203904		2N3904
Q28	8-D4	C6	2N3904	818203904		2N3904

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			RESISTORS All resistors not otherwise designated are 1/4W, 5%, Comp * 1/8W, 1%, Metflm ** 1/8W, 0.1%, Metflm ***1/10W, 1%, Temp Stable, Metflm			
R1	9-B1	C10	1K	817007102		RC07
R2	9-B2	C10	1K	817007102		RC07
R3	9-B2	C10	1K	817007102		RC07
R4	9-C2	C9	10.0K, *	817212100		RN60D
R5	9-C2	C9	4.7K	817007472		RC07
R6	9-C2	C9	10.0K, *	817212100		RN60D
R7	9-B3	C10	1K	817007102		RC07
R8	9-B3	C10	1K	817007102		RC07
R9	9-B3	C9	1K	817007102		RC07
R10	9-A3	B8	47 ohm	817007470		RC07
R11	9-C1	C8	47 ohm	817007470		RC07
R12	9-B3	D9	1K	817007102		RC07
R13	9-B4	D10	470 ohm	817007471		RC07
R14	9-B4	D10	10K	817007103		RC07
R15	9-B4	D9	4.7K	817007472		RC07
R16	9-B5	D10	47K	817007473		RC07
R17	9-B5	D10	47K	817007473		RC07
R18	9-B5	E10	4.7K	817007472		RC07
R19	9-B6	E10	470 ohm	817007471		RC07
R20	9-B6	E9	10K	817007103		RC07
R21	9-B6	E10	1K	817007102		RC07
R22	9-B6	E10	330 ohm	817007331		RC07
R23	9-B7	E10	2.2K	817007222		RC07
R24	9-B7	E10	4.7K	817007472		RC07
R25	9-B7	F10	1K	817007102		RC07
R26	9-B7	F10	4.7K	817007472		RC07
R27	9-B8	F10	1.2K, 1/2W, 5%	817020122		
R28	9-E2	E5	100K	817007104		RC07
R30	9-E2	E5	5.11K, *	817211511		RN60D

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			RESISTORS (continued)			
R31	9-E2	E5	10K	817007103		RC07
R33	9-F2	F5	8.2K	817007822		RC07
R34	9-E3	F5	5.11K, *	817211511		RN60D
R35	9-D3	E5	5.11K, *	817211511		RN60D
R36	9-E3	F5	5.11K, *	817211511		RN60D
R38	9-G2	E4	47 ohm	817007470		RC07
R39	9-G2	E4	47 ohm	817007470		RC07
R40	9-D4	E8	470 ohm	817007471		RC07
R41	9-D5	E8	2.7K	817007272		RC07
R42	9-D5	E9	470 ohm	817007471		RC07
R43	9-D5	E9	2.7K	817007272		RC07
R44	9-D5	E8	47 ohm	817007470		RC07
R45	9-D5	E9	47 ohm	817007470		RC07
R46	9-D6	F8	27K	817007727		RC07
R47	9-C6	F8	10M	817007106		RC07
R48	9-C6	F8	10M	817007106		RC07
R49	9-E6	F9	27K	817007273		RC07
R50	9-E6	F9	10M	817007106		RC07
R51	9-E6	F9	10M	817007106		RC07
R52	9-D7	F9	1K	817007102		RC07
R53	9-E6	F8	10K	817007103		RC07
R54	9-E6	E7	1K	817007102		RC07
R55	9-E5	E7	10.0K, *	817212100		RN60D
R56	9-E5	E7	31.6K, *	817212316		RN60D
R57	9-F5	E7	6.8K	817007682		RC07
R58	9-F5	E6	1K	817007102		RC07
R59	9-G5	E6	10.0K, *	817212100		RN60D
R60	9-G5	E6	31.6K, *	817212316		RN60D
R61	9-G5	E6	31.6K, *	817212316		RN60D
R62	9-G5	E6	10K	817007103		RC07
R64	9-G6	F6	47 ohm	817007470		RC07
R65	9-G6	F6	1M	817007105		RC07

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			RESISTORS (continued)			
R66	9-F6	F7	1K	817007102		RC07
R67	9-E7	F8	4.22K, *	817211422		RN60D
R68	9-E8	F8	511 ohm, *	817210511		RN60D
R69	9-E8	E8	10K	817007103		RC07
R70	9-D9	D7	4.64K, *	817211464		RN60D
R71	9-D9	D7	10K	817007103		RC07
R72	8-B5	C3	2.2K	817007222		RC07
R73	8-B4	C3	100K	817007104		RC07
R74	8-B4	B6	33K	817007333		RC07
R75	8-B3	C7	270 ohm	817007271		RC07
R76	8-B4	C7	10K	817007103		RC07
R78	8-B4	B6	390K	817007394		RC07
R79	8-A5	C7	150K	817007154		RC07
R80	8-B4	B6	12K	817007123		RC07
R81	8-B4	B6	10K	817007103		RC07
R82	8-D5	B7	82K	817007823		RC07
R83	8-D5	B7	82K	817007823		RC07
R84	8-D5	B7	10M	817007106		RC07
R87	8-E5	D8	270K	817007274		RC07
R88	8-E5	D8	150K	817007154		RC07
R89	8-E5	D8	3.9M	817007395		RC07
R90	8-E6	C8	38.3K, *	817212383		RN60D
R91	8-E6	C8	1.2M	817007125		RC07
R92	8-E7	C8	19.6K, *	817212196		RN60D
R95	8-E8	C8	31.6K, *	817212316		RN60D
R96	8-F8	C8	14.7K, *	817212147		RN60D
R97	8-F8	C8	10.0K, *	817212100		RN60D
R98	8-D7	C8	90.0K, *	817212909		RN60D
R99	8-D7	B8	10K	817007103		RC07
R100	8-D8	D8	10K	817007103		RC07
R101	8-D7	D8	4.7K	817007472		RC07
R102	8-C7	D8	100K	817007104		RC07
R103	8-C8	E8	22K	817007223		RC07
R104	8-C7	E8	180K	817007184		RC07
R105	8-B6	D8	15K	817007153		RC07

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			RESISTORS (continued)			
R106	8-B7	D8	100K	817007104		RC07
R107	8-B7	D8	100K	817007104		RC07
R108	8-B8	E8	22K	817007223		RC07
R109	8-A7	D8	39K	817007393		RC07
R110	8-C3	D7	2.2K	817007222		RC07
R111	8-C4	C6	220 ohm	817007221		RC07
R112	8-D3	D5	1K	817007102		RC07
R113	8-D3	D5	10K	817007103		RC07
R114	8-E3	D5	4.7K	817007472		RC07
R115	8-F2	D6	10 ohm	817007100		RC07
R116	8-G2	D6	100K	817007104		RC07
R117	8-G2	D6	100K	817007104		RC07
R118	8-G2	D6	8.2M	817007825		RC07
R119	8-H2	D6	10 ohm	817007100		RC07
R120	8-F3	D6	10K	817007103		RC07
R121	8-G3	D6	10K	817007103		RC07
R122	8-F3	D6	1K	817007102		RC07
R123	8-F3	C5	220 ohm	817007221		RC07
R124	8-H3	C5	220 ohm	817007221		RC07
R125	12-C5	C4	1.5K	817007152		RC07
R126	12-B5	C4	68 ohm, 1W, 5%, W.W.	817002027	99	5043CX68R00J9BV
R127	12-B5	C4	12M	817007126		RC07
R128	12-C5	C4	10K	817007103		RC07
R129	12-C6	C4	680 ohm	817007681		RC07
R130	12-B6	B4	2.2 ohm, 1.5W, W.W.	817002025	37	995-1A-4037
R131	12-C6	D4	3.16K, *	817211316		RN60D
R132	12-C6	D4	500 ohm (POT)	817803501	7	3386P-1-501
R133	12-D6	D4	2.49K, *	817211249		RN60D
R134	12-B7	D4	21.5K, *	817212215		RN60D
R135	12-B7	E4	21.5K, *	817212215		RN60D
R136	12-C7	D4	10K	817007103		RC07
R137	12-C7	C5	19.6K, *	817212196		RN60D
R138	12-D7	C5	270 ohm	817007271		RC07
R139	12-D7	C5	1 ohm, 1.5W, 5%, W.W.	817002026	37	995-1A-4030
R140	12-D8	C5	1K	817007102		RC07

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			RESISTORS (continued)			
R141	12-C8	C5	10K	817007103		RC07
R142	12-B8	C5	2.7K	817007272		RC07
R143	12-C8	C5	2.7K	817007272		RC07
R144	12-C9	D5	10K	817007103		RC07
R145	12-D7	C5	2.2 ohm, 1/2W, 5%	817000029	3	EB22G5
R146	12-F5	B4	150 ohm, 2W, 5%	817042151		RC42
R147	8-F6	C9	2.7K	817007272		RC07
R148	8-F6	C9	3.48K, *	817211348		RN60D
R149	8-G6	C9	1.33K, *	817211133		RN60D
R150	9-E7	F8	10K	817007103		RC07
R151	9-G6	F6	2K Pot, Cermet	817805202	7	3299W-1-202
R152	8-D7	C8	100K	817007104		RC07
R153	9-G5	F6	47 ohm	817007470		RN60D
R154	9-G5	F6	2.15K, *	817211215		RN60D
R155	8-E4	D7	100K	817007104		RC07
R156	8-F5	C7	100K	817007104		RC07
R157	8-D4	C6	1K	817007102		RC07
R158	8-D4	C6	2.7K	817007272		RC07
R159	8-D4	C6	1.5K	817007152		RC07
R160	8-D4	C7	270 ohm	817007271		RC07
R161	12-F5	B3	330 ohm, 1W, 5%	817032331		RC32
S1	12-B1	E1	Switch, Push	815160009	87	82403
U1	9-E1	E5	LM318H	816400037	36	LM318H
U2	9-E2	F5	LM318H	816400037	36	LM318H
U3	9-E3	F5	LM318H	816400037	36	LM318H
U4	9-F5	E7	LM318H	816400037	36	LM318H
U5	9-G5	E6	LM318H	816400037	36	LM318H

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
U6	9-G6	F7	LM318H	816400037	36	LM318H
U7	9-E7	F8	LM310H	816400018	36	LM310H
U8	9-D8	E8	LM310H	816400018	36	LM310H
U10	8-F7	C9	LF355H	816400062		LF355H
U11	8-E9	C9	LM301A	A86050P4	31	A86050P4
U12	8-C7	D8	LM301A	A86050P4	31	A86050P4
U13	8-B7	D9	LM301A	A86050P4	31	A86050P4
U14	8-G2	D6	LM311H	816400026	36	LM311H
U15	8-F4	C6	SN7400N	816370000	55	SN7400N
U16	8-H4	C5	SN7404N	816370004	55	SN7404N
U17	8-H5	B6	SN7474N	816370074	55	SN7474N
U18	8-F4	B5	SN7474N	816370074	55	SN7474N
U19	8-E4	D6	MC4044P	816300054	35	MC4044P
U20	12-C5	C4	U5R-7723-393	816400008	26	U5R-7723-393
U21	12-C7	D4	LM301A	A86050P4	31	A86050P4
VR1			Volt Regulator	816400100	36	LM78L05ACZ

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
AR2	7-C3	C1	Op Amp LM301A	A86050P4	31	A86050P4
AR3	7-C4	B1	Op Amp LM301A	A86050P4	31	A86050P4
AR5	7-E3	C6	Op Amp LM301A	A86050P4	31	A86050P4
AR6	7-E4	B6	Op Amp LM301A	A86050P4	31	A86050P4
AR7	7-A6	B2	Op Amp LM301A	A86050P4	31	A86050P4
AR8	7-B6	C2	Op Amp LM301A	A86050P4	31	A86050P4
AR9	7-C6	C3	Op Amp LM301A	A86050P4	31	A86050P4
AR10	7-D6	B3	Op Amp LM301A	A86050P4	31	A86050P4
AR11	7-E6	B3	Op Amp LM301A	A86050P4	31	A86050P4
AR12	7-F6	C3	Op Amp LM301A	A86050P4	31	A86050P4
AR13	7-G6	C4	Op Amp LM301A	A86050P4	31	A86050P4
AR14	7-G6	B4	Op Amp LM301A	A86050P4	31	A86050P4
AR15	7-D8	B5	Op Amp LM301A	A86050P4	31	A86050P4
			CAPACITORS			
C2	7-B3	C1	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C3	7-C3	C1	.01μF, 500V, 20%, Cer	811570019	48	5GAS-S10
C4	7-C3	C1	.01μF, 500V, 20%, Cer	811570019	48	5GAS-S10
C5	7-B4	B1	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C7	7-E3	C5	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C8	7-F3	C6	.01μF, 500V, 20%, Cer	811570019	48	5GAS-S10
C9	7-F3	C6	.01μF, 500V, 20%, Cer	811570019	48	5GAS-S10
C10	7-E4	B5	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C11	7-A6	C2	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C12	7-B6	C2	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C13	7-C6	C3	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C14	7-D6	C3	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C15	7-E6	C3	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C16	7-F6	C3	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C17	7-F6	C4	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C18	7-G6	C4	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C19	7-D8	C5	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C20	7-E8	C5	.01μF, 500V, 20%, Cer	811570019	48	5GAS-S10
C21	7-E8	B5	.01μF, 500V, 20%, Cer	811570019	48	5GAS-S10
C22	7-F8	C5	15μF, 20V, 10%, Ta	811501156	48	150D156X9020B2
C23	7-F8	C5	15μF, 20V, 10%, Ta	811501156	48	150D156X9020B2

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			DIODES			
CR1	7-B4	C1	A86003P1	A86003P1	31	A86003P1
CR2	7-B4	C1	IN4148	818100003		IN4148
CR3	7-E4	C6	A86003P1	A86003P1	31	A86003P1
CR4	7-E4	C6	IN4148	818100003		IN4148
CR5	7-A7	B2	IN4148	818100003		IN4148
CR6	7-A7	B2	IN4148	818100003		IN4148
CR7	7-B7	C2	IN4148	818100003		IN4148
CR8	7-B7	C2	IN4148	818100003		IN4148
CR9	7-C7	D3	IN4148	818100003		IN4148
CR10	7-C7	D3	IN4148	818100003		IN4148
CR11	7-D7	C3	IN4148	81810003		IN4148
CR12	7-D7	C3	IN4148	81810003		IN4148
CR13	7-E7	B3	IN4148	81810003		IN4148
CR14	7-E7	B3	IN4148	81810003		IN4148
CR15	7-F7	C3	IN4148	81810003		IN4148
CR16	7-F7	C3	IN4148	81810003		IN4148
CR17	7-F7	D4	IN4148	81810003		IN4148
CR18	7-F7	D4	IN4148	81810003		IN4148
CR19	7-G7	C4	IN4148	81810003		IN4148
CR20	7-G7	C4	IN4148	81810003		IN4148
			RESISTORS All resistors not otherwise designated are 1/4W, 5%, Comp * 1/8W, 1%, Metflm ** 1/8W, 0.1%, Metflm ***1/10W, 1%, Temp Stable, Metflm			
R2	7-C2	C1	15M	817007156		RC07
R3	7-C2	B1	50K (POT)	817804503	7	3386W-1-503
R5	7-B2	D1	22K	817007223		RC07
R6	7-B3	C1	22.51K **	817261108	63	RE 1/4C-1 22.51K
R7	7-B4	C1	22.51K **	817261108	63	RE 1/4C-1 22.51K
R8	7-B4	C1	22.51K **	817261108	63	RE 1/4C-1 22.51K
R9	7-B4	C1	45.01K **	817261106	63	RE 1/4C-1 45.01K
R10	7-B4	B1	45.01K **	817261106	63	RE 1/4C-1 45.01K

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			RESISTORS (continued)			
R11	7-A4	B2	50K (POT)	817804503	7	3386W-1-503
R12	7-A4	C1	15M	817007156		RC07
R13	7-C4	C1	22K	817007223		RC07
R15	7-F2	C6	15M	817007156		RC07
R16	7-F2	D6	50K (POT)	817804503	7	3386W-1-503
R18	7-E2	D6	22K	817007223		RC07
R19	7-E3	C6	22.51K **	817261108	63	RE 1/4C-1 22.51K
R20	7-E4	C6	22.51K	817261108	63	RE 1/4C-1 22.51K
R21	7-E4	C6	22.51K **	817261108	63	RE 1/4C-1 22.51K
R22	7-E4	C6	45.01K **	817261106	63	RE 1/4C-1 45.01K
R23	7-E4	B6	45.01K **	817261106	63	RE 1/4C-1 45.01K
R24	7-D4	B6	50K (POT)	817804503	7	3386W-1-503
R25	7-D4	C6	15M	817007156		RC07
R26	7-F4	C6	22K	317007223		RC07
R27	7-A6	C2	45.12K **	817261165	42	PME55
R28	7-A6	C2	464K *	817213464		RN60D
R29	7-A6	B2	50K (POT)	817804503	7	3386W-1-503
R30	7-A6	C2	18M	817007186		RC07
R31	7-A6	C2	18K	817007183		RC07
R32	7-A7	B2	31.62K **	817261126	63	RE 1/4C-131.62K
R33	7-B6	C2	46.92K **	817261167	42	PME55
R34	7-B6	C2	154K *	817213154		RN60D
R35	7-B6	B2	50K (POT)	817804503	7	3386W-1-503
R36	7-B6	D2	18M	817007186		RC07
R37	7-B6	D2	18K	817007183		RC07
R38	7-B7	C2	31.62K **	817261126	63	RE 1/4C-131.62K
R39	7-C6	C3	50.91K **	817261169	42	PME55
R40	7-C6	C3	95.25K **	817261170	42	PME55
R41	7-C6	B3	50K (POT)	817804503	7	3386W-1-503
R42	7-C6	C3	18M	817007186		RC07
R43	7-C6	C3	18K	817007183		RC07
R44	7-C7	C3	31.62K **	817261126	63	RE 1/4C-1 31.62K
R45	7-D6	B3	58.09K **	817261171	42	PME55

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			RESISTORS (continued)			
R46	7-D6	B3	70.78K **	817261172	42	PME55
R47	7-D6	B3	50K (POT)	817804503	7	3386W-1-503
R48	7-D6	B3	18M	817007186		RC07
R49	7-D6	B3	18K	817007183		RC07
R50	7-D7	C3	31.62K **	817261126	63	RE 1/4C-1 31.62K
R51	7-E6	C3	70.78K **	817261172	42	PME55
R52	7-E6	C3	58.09K **	817261171	42	PME55
R53	7-E6	B3	50K (POT)	817804503	7	3386W-1-503
R54	7-E6	C3	18M	817007186		RC07
R55	7-E6	C3	18K	817007183		RC07
R56	7-E7	B3	31.62K **	817261126	63	RE 1/4C-1 31.62K
R57	7-E6	C3	95.25K **	817261170	42	PME55
R58	7-F6	C3	50.91K **	817261169	42	PME55
R59	7-F6	B4	50K (POT)	817804503	7	3386W-1-503
R60	7-F6	D3	18M	817007186		RC07
R61	7-F6	D3	18K	817007183		RC07
R62	7-E7	C3	31.62K **	817261126	63	RE 1/4C-1 31-62K
R63	7-F6	C4	154K *	817213154		RN60D
R64	7-F6	C4	46.92K **	817261167	42	PME55
R65	7-G6	B4	50K (POT)	817804503	7	3386W-1-503
R66	7-G6	C4	18M	817007186		RC07
R67	7-G6	C4	18K	817007183		RC07
R68	7-F7	C4	31.62K **	817261126	63	RE 1/4C-1 31.62K
R69	7-G6	B4	464K *	817213464		RN60D
R70	7-G6	B4	45.12K **	817261165	42	PME55
R71	7-G6	B4	50K (POT)	817804503	7	3386W-1-503
R72	7-G6	B4	18M	817007186		RC07
R73	7-G6	B4	18K	817007183		RC07
R74	7-G7	C4	31.62K **	817261126	63	RE 1/4C-1 31.62K
R75	7-D7	C5	31.62K **	817261126	63	RE 1/4C-1 31.62K
R76	7-C8	C5	45.01K **	817261106	63	RE 1/4C-1 45.01K
R77	7-C8	C5	3.3K	817007332		RC07
R78	7-D8	B5	45.01K **	817261106	63	RE 1/4C-1 45.01K
R79	7-E8	B5	50K (POT)	817804503	7	3386W-1-503
R80	7-E7	C5	12M	817007126		RC07
R81	7-E7	C5	12K	817007123		RC07
R82	7-G7	C5	100K	817007104		RC07

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
AR1	3-B3	B5	Op Amp LM108AH	816400070	36	LM108AH
AR2	3-D5	C5	Op Amp LM301A	A86050P4	31	A86050P4
AR3	3-B6	C4	Op Amp LM301A	A86050P4	31	A86050P4
AR4	3-F2	D2	Op Amp LM319H	816400056	36	LM319H
			CAPACITORS			
C1	3-A2	D3	22μF, 15V, 10%, Ta	811501103	48	150D226X9015B2
C2	3-A2	D3	22μF, 15V, 10%, Ta	811501103	48	150D226X9015B2
C3	3-B2	D4	22μF, 15V, 10%, Ta	811501103	48	150D226X9015B2
C4	3-B2	D4	22μF, 15V, 10%, Ta	811501103	48	150D226X9015B2
C5	3-B3	C3	.1μF, 50V, 5%, Polycarb	811540035	22	636A1A104J
C6	3-B4	B4	.1μF, 200V, 1%, Polycarb	811540028	22	W625B1C104F
C7	3-C4	B4	.1μF, 200V, 1%, Polycarb	811540028	22	W625B1C104F
C8	3-C4	C3	.1μF, 50V, 5%, Polycarb	811540035	22	636A1A104J
C9	3-D4	C5	.1μF, 200V, 10%, Mylar	811553006	22	W230B1C-104K
C10	3-D5	C5	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C11	3-C5	C6	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C12	3-B5	B5	100pF, 1000V, 20%, Cer	811572011	48	10TS-T10
C13	3-B5	B6	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C14	3-C6	C6	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C15	3-C6	C4	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C16	3-B6	C4	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C17	3-B7	C5	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C18	3-C9	C5	.01μF, 500V, 20%, Cer	811570019	48	5GAS-S10
C19	3-C9	C5	.01μF, 500V, 20%, Cer	811570019	48	5GAS-S10
C20	3-F2	D2	15μF, 20V, 10%, Ta	811501156	48	150D156X9020B2
C21	3-F3	D1	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C22	3-G3	D2	47pF, 1000V, 20%, Cer	811572005	48	10TS-Q47
C23	3-G3	D2	15μF, 20V, 10%, Ta	811501156	48	150D156X9020B2
C24	3-F5	C2	.1μF, 100V, 20%, Cer	811570014	25	8131-100-651-104M
C25	3-E6	B4	47μF, 20V, 10%, Ta	811501162	48	150D476X9020R2
C26	3-F4	C2	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C27	3-G4	C1	100pF, 500V, 5%, Sil Mica	811581008	79	DM-15D101J
C28	3-H4	B2	47μF, 20V, 10%, Ta	811501162	48	150D476X9020R2
C29	3-G4	C2	15pF, 500V, 5%, Sil Mica	811581029	79	DM-15C150J
C30	3-G6	B1	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C31	3-G6	B1	15μF, 20V, 10%, Ta	811501156	48	150D156X9020B2
C32	3-D8	D5	47μF, 20V, 10%, Ta	811501162	48	150D476X9020R2
C33	3-E8	D5	47μF, 20V, 10%, Ta	811501162	48	150D476X9020R2

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			DIODES			
CR1	3-B8	C4	IN4148	818100003		IN4148
CR2	3-C8	C4	IN4148	818100003		IN4148
CR4	3-E6	B3	IN4148	818100003		IN4148
CR5	3-F6	B3	IN4148	818100003		IN4148
CR6	3-G5	C3	IN4148	818100003		IN4148
CR7	3-F5	C3	IN4148	818100003		IN4148
CR8	3-G6	C1	IN753A (Zener)	818150005		IN753A
L1	3-D9	C6	Choke 10μH	811800024	20	1537-36
L2	3-E9	C5	Choke 10μH	811800024	20	1537-36
			TRANSISTORS			
Q1A	3-A3	B3	A86150P1 (SD 214)	A86150P1	31	A86150P1
Q1B	3-B3	B4	A86150P1 (SD 214)	A86150P1	31	A86150P1
Q1C	3-B3	C3	A86150P1 (SD 214)	A86150P1	31	A86150P1
Q1D	3-C3	C4	A86150P1 (SD 214)	A86150P1	31	A86150P1
Q5	3-C5	B6	2N3904	818203904		2N3904
Q6	3-B5	B6	FET	A86013P8	31	A86031P8
Q7	3-C6	C6	2N3904	818203904		2N3904
Q8	3-B7	C5	2N3904	818203904		2N3904
Q9	3-C7	C5	FET	A86013P8	31	A86013P8
Q10	3-B8	C5	2N3904	818203904		2N3904
Q11	3-C8	C5	2N3906	818203906		2N3906
Q12	3-F4	B1	MPS-2369	818700033	35	MPS-2369
Q13	3-F4	B2	MPS-2369	818700033	35	MPS-2369
Q14	3-F5	B2	MPS-2369	818700033	35	MPS-2369
Q15	3-E6	B3	2N3904	818203904		2N3904
Q16	3-G4	C2	MPS-2369	818700033	35	MPS-2369
Q17	3-G5	C2	MPS-2369	818700033	35	MPS-2369
Q18	3-F5	C3	2N3904	818203904		2N3904
Q19	3-H5	C2	2N3904	818203904		2N3904

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			RESISTORS All resistors unless otherwise designated are 1/4W, 5%, Comp * 1/8W, 1%, Metflm ** 1/8W, 0.1%, Metflm ***1/10W, 1%, Temp Stable, Metflm			
R1	3-B2	D3	6.81K *	817211681		RN60D
R2	3-A2	D3	6.81K * *	817261191		RN60D
R3	3-C2	D3	6.81K *	817211681		RN60D
R4	3-B2	D3	6.81K **	817211191		RN60D
R5	3-B4	B5	100 ohm	817007101		RC07
R7	3-B4	B5	12.30K	817261192		RN60D
R8	3-B4	B5	10.0K *	817212100		RN60D
R9	3-B4	B5	10.0K *	817212100		RN60D
R10	3-C4	B5	100 ohm	817007100		RC07
R12	3-C4	B5	13.3K **	817261192		RN60D
R13	3-D4	C5	34.8K *	817212348		RN60D
R14	3-D4	C6	100K *	817213100		RN60D
R15	3-D4	C5	100K *	817213100		RN60D
R16	3-D4	C5	47K	817007473		RC07
R17	3-D5	C6	56K	817007563		RC07
R18	3-C4	B5	22M	817007226		RC07
R19	3-C5	B5	22M	817007226		RC07
R20	3-C6	C6	15K	817007153		RC07
R21	3-C6	C6	6.8K	817007682		RC07
R22	3-B6	C4	22.51K **	817261108	63	RE 1/4C-1 22.51K
R23	3-B6	C4	22.51K **	817261108	63	RE 1/4C-1 22.51K
R24	3-C6	C4	11.0K *	817212110		RN60D
R25	3-C7	C4	56.2K *	817212562		RN60D
R26	3-C8	C4	51.1K *	817212511		RN60D
R27	3-C8	C4	1M	817007105		RC07
R28	3-C8	C4	1M	817007105		RC07
R29	3-G2	D2	4.7K	817007472		RC07
R30	3-F2	D2	1K	817007102		RC07

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			RESISTORS (continued)			
R31	3-G2	D2	5.6K	817007562		RC07
R32	3-G2	D2	39 ohm	817007390		RC07
R33	3-G3	D2	6.8K	817007682		RC07
R34	3-F3	D1	3.9K	817007392		RC07
R35	3-F4	B1	56 ohm	817007560		RC07
R36	3-E4	B2	5.6K	817007562		RC07
R37	3-E5	B2	5.6K	817007562		RC07
R38	3-E5	B3	1.5K	817007152		RC07
R39	3-E6	B4	39 ohm	817007390		RC07
R40	3-E7	B3	10K	817007103		RC07
R41	3-G4	C1	56 ohm	817007560		RC07
R42	3-H4	C1	470ohm, 1W, 5%	817032471		RC32
R43	3-G4	C2	5.6K	817007562		RC07
R44	3-G5	C3	1.5K	817007152		RC07
R45	3-H5	C2	680 ohm	817007681		RC07
R46	3-H5	C2	680 ohm	817007681		RC07
R47	3-G7	C3	10K	817007103		RC07
R48	3-A2	D3	Trim			
R49	3-B2	D3	Trim			

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
AR1	5-B3	B5	Op Amp LM108AH	816400070	36	LM108AH
AR2	5-D5	C5	Op Amp LM301A	A86050P4	31	A86050P4
AR3	5-B6	C4	Op Amp LM301A	A86050P4	31	A86050P4
AR4	5-F2	D2	Op Amp LM319H	816400056	36	LM319H
			CAPACITORS			
C1	5-A2	D3	22μF, 15V, 10%, Ta	811501103	48	150D226X9015B2
C2	5-A2	D3	22μF, 15V, 10%, Ta	811501103	48	150D226X9015B2
C3	5-B2	D4	22μF, 15V, 10%, Ta	811501103	48	150D226X9015B2
C4	5-B2	D4	22μF, 15V, 10%, Ta	811501103	48	150D226X9015B2
C5	5-B3	C3	.1μF, 50V, 5%, Polycarb	811540035	22	636A1A104J
C6	5-B4	B4	.1μF, 200V, 1%, Polycarb	811540028	22	W625B1C104F
C7	5-C4	B4	.1μF, 200V, 1%, Polycarb	811540028	22	W625B1C104F
C8	5-C4	C3	.1μF, 50V, 5%, Polycarb	811540035	22	636A1A104J
C9	5-D4	C5	.1μF, 200V, 10%, Mylar	811553006	22	W230B1C-104K
C10	5-D5	C5	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C11	5-C5	C6	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C12	5-B5	B5	100pF, 1000V, 20%, Cer	811572011	48	10TS-T10
C13	5-B5	B6	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C14	5-C6	C6	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C15	5-C6	C4	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C16	5-B6	C4	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C17	5-B7	C5	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C18	5-C9	C5	.01μF, 500V, 20%, Cer	811570019	48	5GAS-S10
C19	5-C9	C5	.01μF, 500V, 20%, Cer	811570019	48	5GAS-S10
C20	5-F2	D2	15μF, 20V, 10%, Ta	811501156	48	150D156X9020B2
C21	5-F3	D1	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C22	5-G3	D2	47pF, 1000V, 20%, Cer	811572005	48	10TS-Q47
C23	5-G3	D2	15μF, 20V, 10%, Ta	811501156	48	150D156X9020B2
C24	5-F5	C2	.1μF, 100V, 20%, Cer	811570014	25	8131-100-651-104M
C25	5-E6	B4	47μF, 20V, 10%, Ta	811501162	48	150D476X9020R2
C26	5-F4	C2	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C27	5-G4	C1	100pF, 500V, 5%, Sil Mica	811581008	79	DM-15D101J
C28	5-H4	B2	47μF, 20V, 10%, Ta	811501162	48	150D476X9020R2
C29	5-G4	C2	15pF, 500V, 5%, Sil Mica	811581029	79	DM-15C150J
C30	5-G6	B1	.05μF, 100V, 20%, Cer	811570007	48	TG-S50
C31	5-G6	B1	15μF, 20V, 10%, Ta	811501156	48	150D156X9020B2
C32	5-D8	D5	47μF, 20V, 10%, Ta	811501162	48	150D476X9020R2
C33	5-E8	D5	47μF, 20V, 10%, Ta	811501162	48	150D476X9020R2

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			DIODES			
CR1	5-B8	C4	IN4148	818100003		IN4148
CR2	5-C8	C4	IN4148	818100003		IN4148
CR4	5-E6	B3	IN4148	818100003		IN4148
CR5	5-F6	B3	IN4148	818100003		IN4148
CR6	5-G5	C3	IN4148	818100003		IN4148
CR7	5-F5	C3	IN4148	818100003		IN4148
CR8	5-G6	C1	IN753A (Zener)	818150005		IN753A
L1	5-D9	C6	Choke 10μH	811800024	20	1537-36
L2	5-E9	C5	Choke 10μH	811800024	20	1537-36
			TRANSISTORS			
Q1A	5-A3	B3	A86150P1 (SD 214)	A86150P1	31	A86150P1
Q1B	5-B3	B4	A86150P1 (SD 214)	A86150P1	31	A86150P1
Q1C	5-B3	C3	A86150P1 (SD 214)	A86150P1	31	A86150P1
Q1D	5-C3	C4	A86150P1 (SD 214)	A86150P1	31	A86150P1
Q5	5-C5	B6	2N3904	818203904		2N3904
Q6	5-B5	B6	FET	A86013P8	31	A86031P8
Q7	5-C6	C6	2N3904	818203904		2N3904
Q8	5-B7	C5	2N3904	818203904		2N3904
Q9	5-C7	C5	FET	A86013P8	31	A86013P8
Q10	5-B8	C5	2N3904	818203904		2N3904
Q11	5-C8	C5	2N3906	818203906		2N3906
Q12	5-F4	B1	MPS-2369	818700033	35	MPS-2369
Q13	5-F4	B2	MPS-2369	818700033	35	MPS-2369
Q14	5-F5	B2	MPS-2369	818700033	35	MPS-2369
Q15	5-E6	B3	2N3904	818203904		2N3904
Q16	5-G4	C2	MPS-2369	818700033	35	MPS-2369
Q17	5-G5	C2	MPS-2369	818700033	35	MPS-2369
Q18	5-F5	C3	2N3904	818203904		2N3904
Q19	5-H5	C2	2N3904	818203904		2N3904

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			RESISTORS All resistors unless otherwise designated are 1/4W, 5%, Comp * 1/8W, 1%, Metflm ** 1/8W, 0.1%, Metflm ***1/10W, 1%, Temp Stable, Metflm			
R1	5-B2	D3	6.81K *	817211681		RN60D
R2	5-A2	D3	6.81K **	817261191		RN60D
R3	5-C2	D3	6.81K *	817211681		RN60D
R4	5-B2	D3	6.81K **	817261191		RN60D
R5	5-B4	B5	100 ohm	817007101		RC07
R7	5-B4	B5	12.30K	817261192		RN60D
R8	5-B4	B5	10.0K *	817212100		RN60D
R9	5-B4	B5	10.0K *	817212100		RN60D
R10	5-C4	B5	100 ohm	817007100		RC07
R12	5-C4	B5	13.3K **	817261192		RN60D
R13	5-D4	C5	34.8K *	817212348		RN60D
R14	5-D4	C6	100K *	817213100		RN60D
R15	5-D4	C5	100K *	817213100		RN60D
R16	5-D4	C5	47K	817007473		RC07
R17	5-D5	C6	56K	817007563		RC07
R18	5-C4	B5	22M	817007226		RC07
R19	5-C5	B5	22M	817007226		RC07
R20	5-C6	C6	15K	817007153		RC07
R21	5-C6	C6	6.8K	817007682		RC07
R22	5-B6	C4	22.51K **	817261108	63	RE 1/4C-1 22.51K
R23	5-B6	C4	22.51K **	817261108	63	RE 1/4C-1 22.51K
R24	5-C6	C4	11.0K *	817212110		RN60D
R25	5-C7	C4	56.2K *	817212562		RN60D
R26	5-C8	C4	51.1K *	817212511		RN60D
R27	5-C8	C4	1M	817007105		RC07
R28	5-C8	C4	1M	817007105		RC07
R29	5-G2	D2	4.7K	817007472		RC07
R30	5-F2	D2	1K	817007102		RC07

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			RESISTORS (continued)			
R31	5-G2	D2	5.6K	817007562		RC07
R32	5-G2	D2	39 ohm	817007390		RC07
R33	5-G3	D2	6.8K	817007682		RC07
R34	5-F3	D1	3.9K	817007392		RC07
R35	5-F4	B1	56 ohm	817007560		RC07
R36	5-E4	B2	5.6K	817007562		RC07
R37	5-E5	B2	5.6K	817007562		RC07
R38	5-E5	B3	1.5K	817007152		RC07
R39	5-E6	B4	39 ohm	817007390		RC07
R40	5-E7	B3	10K	817007103		RC07
R41	5-G4	C1	56 ohm	817007560		RC07
R42	5-H4	C1	470ohm, 1W, 5%	817032471		RC32
R43	5-G4	C2	5.6K	817007562		RC07
R44	5-G5	C3	1.5K	817007152		RC07
R45	5-H5	C2	680 ohm	817007681		RC07
R46	5-H5	C2	680 ohm	817007681		RC07
R47	5 G7	C3	10K	817007103		RC07
R48	5-A2	D3	Trim			
R49	5-B2	D3	Trim			

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REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
AR1	4-C4	B2	LM108AH	816400070	36	LM108AH
AR2	4-C7	C3	LM308H	816400003	36	LM308H
			CAPACITORS			
C1	4-C3	C2	1μF, 35V, 10%, Sol Ta	811501195	48	150D105X9035A2
C2	4-C4	B2	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C3	4-C7	C4	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C4	4-A8	C4	15μF, 20V, 10%, Sol Ta	811501156	48	150D156X9020B2
C5	4-A8	C4	15μF, 20V, 10%, Sol Ta	811501156	48	150D156X9020B2
			DIODES			
CR1	4-B4	B3	IN4148	818100003		IN4148
CR2	4-D5	C3	IN4148	818100003		IN4148
CR3	4-D5	C3	IN4148	818100003		IN4148
CR4	4-B7	B3	IN4148	818100003		IN4148
CR5	4-D8	B3	IN4148	818100003		IN4148
CR6	4-D8	B3	IN4148	818100003		IN4148
K1	4-D7	C4	Relay	814500014	24	1A5AHH
			RESISTORS All resistors unless otherwise designated are 1/4W, 5%, Comp * 1/8W, 1%, Metflm ** 1/8W, 0.1%, Metflm ***1/10W, 1%, Temp Stable, Metflm			
R1	4-C2	C2	28.7K **	817261193		RN60D
R2	4-C2	C2	56.27K **	817261105	63	RE 1/4 C-1 56.27K
R3	4-C2	C2	56.27K **	817261105	63	RE 1/4 C-1 56.27K
R4	4-C2	C2	270K	817007274		RC07
R5	4-B2	C2	10K	817007103		RC07

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			RESISTORS			
R6	4-C3	C2	1.0M *	817214100		RN60D
R7	4-C2	C2	110K *	817213110		RN60D
R8	4-C3	C2	47M	817000006	3	CB4765
R9	4-C3	B2	50K, (POT)	817806503	7	3299X-1-503
R10	4-C3	C2	10K	817007103		RC07
R11	4-B3	C2	10K	817007103		RC07
R12	4-B3	C2	47M	817000006	3	CB4765
R13	4-B4	B3	50K, (POT)	817806503	7	3299X-1-503
R14	4-B4	B2	150K	817007154		RC07
R15	4-D4	C3	287K **	817261194		RN60D
R16	4-B4	C3	10.00K **	817261048	63	REA 1/8, 10K C-1
R17	4-C4	B3	100.0K **	817261050	63	REA 1/8, 100K, C-1
R18	4-C4	B3	909K *	817213909		RN60D
R19	4-C4	B3	11.25K **	817261113	63	RE 1/4 C-1 11.25K
R20	4-D5	C3	56.2K *	817212562		RN60D
R21	4-D5	C3	42.2K *	817212422		RN60D
R22	4-B6	C3	10K	817007103		RC07
R23	4-B6	C3	147K	817213147		RN60D
R24	4-B6	C3	4.7K	817007472		RC07
R25	4-B6	C3	750K *	817213750		RN60D
R26	4-C6	C3	68M	817000007	3	CB6865
R27	4-C7	C3	1K	817007102		RC07
R28	4-C7	C3	2.2M	817007225		RC07
R29	4-C7	B3	50K, (POT)	817804503	7	3386W-1-503
R30	4-B7	C3	10K	817007103		RC07
R31	4-B7	C3	47M	817000006	3	CB4765
R32	4-B7	B4	50K, (POT)	817804503	7	3386W-1-503
R33	4-B8	B3	150K	817007154		RC07
R34	4-D7	B3	147K **	817261195		RN60D
R35	4-D8	B4	56.2K *	817212562		RN60D
R36	4-D8	B4	42.2K *	817212422		RN60D
R37	4-C2	D3	1.5K	817007152		RC07
R38	4-C2	D3	1.5K	817007152		RC07

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REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
AR1	6-C4	B2	LM108AH	816400070	36	LM108AH
AR2	6-C7	C3	LM308H	816400003	36	LM308H
			CAPACITORS			
C1	6-C3	C2	33μF, 10V, 10%, Sol Ta	811501067	48	150D336X9010B2
C2	6-C4	B2	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C3	6-C7	C4	33pF, 1000V, 20%, Cer	811572004	48	10TS-Q33
C4	6-A8	C4	15μF, 20V, 10%, Sol Ta	811501156	48	150D156X9020B2
C5	6-A8	C4	15μF, 20V, 10%, Sol Ta	811501156	48	150D156X9020B2
			DIODES			
CR1	6-B4	B3	IN4148	818100003		IN4148
CR2	6-D5	C3	IN4148	818100003		IN4148
CR3	6-D5	C3	IN4148	818100003		IN4148
CR4	6-B7	B3	IN4148	818100003		IN4148
CR5	6-D8	B3	IN4148	818100003		IN4148
CR6	6-D8	B3	IN4148	818100003		IN4148
K1	6-D7	C4	Relay	814500014	24	1A5AHH
			RESISTORS			
			All resistors unless otherwise designated are 1/4W, 5%, Comp * 1/8W, 1%, Metflm ** 1/8W, 0.1%, Metflm ***1/10W, 1%, Temp Stable, Metflm			
R1	6-C2	C2	28.7K **	817261193		RN60D
R2	6-C2	C2	56.27K **	817261105	63	RE 1/4 C-1 56.27K
R3	6-C2	C2	56.27K **	817261105	63	RE 1/4 C-1 56.27K
R4	6-C2	C2	270K	817007274		RC07
R5	6-B2	C2	10K	817007103		RC07

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			RESISTORS			
R6	6-C3	C2	1.0M *	817214100		RN60D
R7	6-C2	C2	110K *	817213110		RN60D
R8	6-C3	C2	47M	817000006	3	CB4765
R9	6-C3	B2	50K, (POT)	817806503	7	3299X-1-503
R10	6-C3	C2	10K	817007103		RC07
R11	6-B3	C2	10K	817007103		RC07
R12	6-B3	C2	47M	817000006	3	CB4765
R13	6-B4	B3	50K, (POT)	817806503	7	3299X-1-503
R14	6-B4	B2	150K	817007154		RC07
R15	6-D4	C3	287K **	817261194		RN60D
R16	6-B4	C3	10.00K **	817261048	63	REA 1/8, 10K C-1
R17	6-C4	B3	100.0K **	817261050	63	REA 1/8, 100K, C-1
R18	6-C4	B3	909K *	817213909		RN60D
R19	6-C4	B3	11.25K **	817261113	63	RE 1/4 C-1 11.25K
R20	6-D5	C3	56.2K *	817212562		RN60D
R21	6-D5	C3	42.2K *	817212422		RN60D
R22	6-B6	C3	10K	817007103		RC07
R23	6-B6	C3	147K	817213147		RN60D
R24	6-B6	C3	4.7K	817007472		RC07
R25	6-B6	C3	750K *	817213750		RN60D
R26	6-C6	C3	68M	817000007	3	CB6865
R27	6-C7	C3	1K	817007102		RC07
R28	6-C7	C3	2.2M	817007225		RC07
R29	6-C7	B3	50K, (POT)	817804503	7	3386W-1-503
R30	6-B7	C3	10K	817007103		RC07
R31	6-B7	C3	47M	817000006	3	CB4765
R32	6-B7	B4	50K, (POT)	817804503	7	3386W-1-503
R33	6-B8	B3	150K	817007154		RC07
R34	6-D7	B3	147K **	817261195		RN60D
R35	6-D8	B4	56.2K *	817212562		RN60D
R36	6-D8	B4	42.2K *	817212422		RN60D
R37	6-C2	D3	1.5K	817007152		RC07
R38	6-C2	D3	1.5K	817007152		RC07

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			CAPACITORS			
C1	2-G2	C5	15pF, 500V, 5%, Sil Mica	811581010	79	DM-10C150J
C2	2-F2	C5	680pF, 500V, 5%, Sil Mica	811581017	79	DM-15D681J
C3	2-F2	C4	3300pF, 500V, 5%, Sil Mica	811581065	79	DM-19D332J
C4	2-F2	C5	180pF, 500V, 1%, Sil Mica	811581039	79	DM15D181F
C5	2-G3	C5	15μF, 20V, 10%, Ta	811504020	48	196D-156X9020KA1
C6	2-G2	D5	100pF, 500V, 1%, Silver Mica	811581050	79	DM15D101F
C7	2-H3	C5	15μF, 20V, 10%, Ta	811504020	48	196D-156X9020KA1
			DIODES			
CR1	2-G2	C5	Low Leakage	A86003P1	31	A86003P1
CR2	2-G2	C5	Low Leakage	A86003P1	31	A86003P1
			RESISTORS			
			All resistors unless otherwise designated are 1/4W, 5%, Comp * 1/8W, 1%, Metflm ** 1/8W, 0.1%, Metflm ***1/10W, 1%, Temp Stable, Metflm			
R1	2-F2	C5	1K **	817261042	63	REA 1/8, 1.0K C-1
R2	2-G3	C5	220 ohm	817007221		RC07
R3	2-G3	C5	100 ohm	817007101		RC07
R4	2-H3	C5	220 ohm	817007221		RC07
R5	2-F2	D4	100K **	817261050	63	REA 1/8, 100K C-1
R6	2-F3	C5	10 ohm *	817219100		RN60D
R7	2-G2	D5	68 ohm, 1/2W, 5%	817002027	99	5043X68R00J9BV
U1	2-G3	C5	OP Amp LF357H	816400064	36	LF357H

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			CAPACITORS			
C1	2-C3	C5	.0022μF, 100V, 10%, Myflm	811551008	28	61-F10AA222
C2	2-C3	C4	.0068μF, 100V, 10%, Myflm	811551035	28	61-F10AA682
C3	2-C2	C5	.1μF, 200V, 1%, Polycarb	811540028	22	W625B1C104F
C4	2-D2	C5	.1μF, 200V, 1%, Polycarb	811540028	22	W625B1C104F
C5	2-C5	B4	.0068μF, 100V, 10%, Myflm	811551035	28	61-F10AA682
C6	2-B6	B5	.0022μF, 100V, 10%, Myflm	811551008	28	61-F10AA222
C7	2-A8	D3	47μF, 20V, 10%, Ta	811504021	48	196D-476X9020LA3
C8	2-G8	B2	47μF, 20V, 10%, Ta	811504021	48	196D-476X9020LA3
C9	2-D3	C4	5pF, 1000V, ±10%, Cer	811572021	48	10TSV50
			DIODES			
CR1	2-C2	B5	A86003P1	A86003P1	31	A86003P1
CR2	2-C2	C5	A86003P1	A86003P1	31	A86003P1
CR3	2-D2	B5	A86003P1	A86003P1	31	A86003P1
CR4	2-D2	C5	A86003P1	A86003P1	31	A86003P1
K1	2-D4	B3	Relay (SPST)	814500014	24	1A5AHH
K2	2-D4	B3	Relay (SPST)	814500014	24	1A5AHH
			TRANSISTORS			
Q1	2-C3,6	C4	U402	818700043		U402
Q2	2-B3	C4	A86164P1	A86164P1	31	A86164P1
Q3	2-B6	B4	A86164P1	A86164P1	31	A86164P1
Q4	2-C3	C4	2N5460 (FET)	818205460		2N5460
Q5	2-C6	B4	2N5460 (FET)	818205460		2N5460
Q6	2-C4	C4	2N3904	818203904		2 N3904
Q7	2-C5	B4	2 N3904	818203904		2N3904
Q8	2-D4	C3	TIS-75 (FET)	818700009	55	TIS-75
Q9	2-D5	C3	TIS-75 (FET)	818700009	55	TIS-75
Q10	2-E4	C3	A86148P1	A86148P1	31	A86148P1
Q11	2-E5	C3	A86148P1	A86148P1	31	A86148P1
Q12	2-F5	C3	2N3904	818203904		2N3904
Q13	2-B4	C4	2N3906	818203906		2N3906
Q14	2-B6	B4	2N3906	818203906		2N3906
Q15	2-B7	C4	A86164P1	A86164P1	31	A86164P1

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			TRANSISTORS (continued)			
Q16	2-B6	B4	A86164P1	A86164P1	31	A86164P1
Q17	2-F7	C2	2N3904	818203904		2N3904
Q18	2-F7	C3	A86148P1	A86148P1	31	A86148P1
Q19	2-F5	C3	2N3904	818203904		2N3904
Q20	2-F8	C3	2N3904	818203904		2N3904
Q21	2-D8	C3	TIS97	818700046		TIS97
			RESISTORS All resistors unless otherwise designated are 1/4W, 5%, Comp * 1/8W, 1%, Metflm ** 1/8W, 0.1%, Metflm ***1/10W, 1%, Temp Stable, Metflm			
R1	2-A4	C4	1.47K, *	817211147		RN60D
R2	2-B3	C4	1.307K, **	817261010	63	REA 1/8, 1.307K C-1
R3	2-B3	C5	12 ohm	817007120		RC07
R4	2-C3	C4	1K *	817211100		RN60D
R5	2-C3	C4	12 ohm	817007120		RC07
R6	2-C2	C5	220 ohm	817007221		RC07
R7	2-D2	B5	150 ohm	817007151		RC07
R8	2-E2	C5	100M	817000008	3	CB1075
R9	2-E3	C5	10M, 1/4W, 1%	817200029	99	SPR5053YL100M00F
R10	2-E3	C5	10M, 1/4W, 1%	817200029	99	SPR5053YL100M00F
R11	2-D4	C4	316.2 ohm, **	817261002	63	REA 1/8, 316.2 ohm C1
R12	2-D4	B3	2.813K, **	817261119	63	RE 1/4 C-1 2.813K
R13	2-D4	B3	75.0 ohm	817219750		RN60D
R14	2-D5	B3	6.838K, **	817261020	63	REA 1/8, 6.838K C-1
R15	2-D5	B3	90.9 ohm	817219909		RN60D
R16	2-A6	B5	1.47K *	817211147		RN60D
R17	2-A7	B5	1.47K *	817211147		RN60D
R18	2-A7	D4	1.47K *	817211147		RN60D
R19	2-B6	C5	1.307K, **	817261010	63	REA 1/8, 1.307K C-1
R20	2-C6	B4	1K *	817211100		RN60D

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			RESISTORS (continued)			
R21	2-B6	B5	12 ohm	817007120		RC07
R22	2-C5	B4	12 ohm	817007120		RC07
R23	2-D7	C2	5.11K, *	817211511		RN60D
R24	2-E4	C3	150 ohm	817007151		RC07
R25	2-E4	C3	1.62K *	817211162		RN60D
R26	2-E5	C3	150 ohm	817007151		RC07
R27	2-E5	C3	1.62K *	817211162		RN60D
R28	2-E6	C3	2.87K *	817211287		RN60D
R29	2-E6	C3	2.87K *	817211287		RN60D
R30	2-F6	C3	1.10K, *	817211110		RN60D
R31	2-F6	C3	1.00K, *	817211100		RN60D
R32	2-F7	C2	1.96K, *	817211196		RN60D
R33	2-F7	C2	1.96K, *	817211196		RN60D
R34	2-F8	C3	237 ohm, *	817210237		RN60D
R35	2-F5	C3	133 ohm, *	817210133		RN60D
R36	2-E2	B6	68 ohm, 1/2W, 5%	817002027	99	5043CX68R00J9BV
R37	2-E7	C2	220 ohm	817007221		RC07
R38	2-C4	B3	220 ohm	817007221		RC07
R39	2-C5	B3	150 ohm	817007151		RC07

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			CAPACITORS			
C1			0.1μF, 100V, 20%	811570036		
C2			0.1μF, 100V, 20%	811570036		
C3			1μF, 35V, 10%	811504028		
C4			1μF, 35V, 10%	811504028		
C5			15μF, 20V, 10%	811504020		
C6			15μF, 20V, 10%	811504020		
C7			15μF, 20V, 10%	811504020		
C8			.022μF, 100V, 10%	811551017		
C9			.22μF, 200V, 1%	811540049		
C10			.01μF, 100V, 10%	811551020		
			DIODES			
CR1			IN4148	818100003		IN4148
J1			Connector, 14 Pin Dip Socket	812129113		
J2			Connector, 20 pin DIL 2x10	812122223		
			TRANSISTORS			
Q1			2N3904	818203904		
Q2			MPS-A14	818700031		
Q3			MPS-A14	818700031		
Q4			MPS-A14	818700031		
Q5			MPS-A14	818700031		
Q6			2N2905	818202905		
			RESISTORS			
R1			2.2K, 1/4W, 5%	817007222		
R2			9.09K, 1/8W, 1%	817211909		
R3			1.00K, 1/8W, 1%	817211100		
R4			3.3K, 1/4W, 5%	817007332		
R5			6.8M, 1/4W, 5%	817007685		

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			RESISTORS (Continued)			
R6			50K Pot	817804503		
R7			10K Pot (18T)	817801126		
R8			6.8M, 1/4W, 5%	817007685		
R9			82.5K, 1/8W, 1%	817212825		
R10			100K, 1/4W, 5%	817007104		
R11			162K, 1/8W, 1%	817213162		
R12			33K, 1/4W, 5%	817007333		
R13			3.9K, 1/4W, 5%, CF	817070392		
R14			3.3K, 1/4W, 5%	817007332		
R15			22K, 1/4W, 5%, CF	817070223		
R16			22K, 1/4W, 5%, CF	817070223		
R17			22K, 1/4W, 5%, CF	817070223		
R18			22K, 1/4W, 5%, CF	817070223		
R19			2.2K, 1/4W, 5%	817007222		
R20			220 ohm, 1/4W, 5%	817007221		
R21			100 ohm, 1/4W, 5%, CF	817070101		
R22			100 ohm x 8, DIP, Indiv	817400028		
			INTEGRATED CIRCUITS			
U1			LM7805	816450006		
U2			LM7812	816400086		
U3			LM7912	816400084		
U4			LM3999Z	816400065		
U5			LD111A	816400118		
U6			LD110	816300183		
U7			CD4093BE	816374093		
U8			CD4511BE	816374551		
U9			CD4049BE	816374049		

FRONT PANEL ASSEMBLY D42042G1 397EO

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
A12	11-E8		Asm Digital Display	B23080G1	31	B23080G1
DS1	11-D10	A2	Seg Display	812975006	83	5082-7616
DS2	11-D9	A2	7 Seg Display	812975005	83	5082-7613
DS3	11-D9	A3	7 Seg Display	812975005	83	5082-7613
DS4	11-D8	A3	7 Seg Display	812975005	83	5082-7613
J1	11-E8	A2	14 Pin Dip Socket	812129113	101	CA-14S-10SD
J2	11-D10	A2	14 Pin Dip Socket	812129113	101	CA-14S-10SD
J3	11-D9	A2	14 Pin Dip Socket	812129113	101	CA-14S-10SD
J4	11-D9	A3	14 Pin Dip Socket	812129113	101	CA-14S-10SD
J5	11-D8	A3	14 Pin Dip Socket	812129113	101	CA-14S-10SD
DS1	12-D4		Diode, Light Emit GRN	818149007	78	521-9203
DS2	8-F7		Diode, Light Emit RED	818149006	78	521-9165
DS3	12-F4		Diode, Light Emit RED	818149006	78	521-9165
DS4	10-E7		Diode, Light Emit YEL	818149013	102	MV5353
DS5	12-D5		Meter Lamp, G.E. 346, 18V	813900026	28	346
DS6	12-D5		Meter Lamp, G.E. 346, 18V	813900026	28	346
J1	8-C1		Connector, BNC	812130110	19	30355-1
J2	10-F8		Connector, BNC	812130110	19	30355-1
J3	1-A1		Connector, BNC	812130110	19	30355-1
M1	10-F7		Meter	C88462P1	31	C88462P1
R1	10-E8		Resistor, POT, 50K, 10%	817802004	7	3856A-282-503A
R2	1-B5		Resistor, POT, 10K, 5%	817500055	7	35095-8-103
R3	11-G3		Resistor, POT, 1K, 10%	817600054	3	WAZGO40P102KA
R4	1-A3		Resistor, 68 ohm, 1/4W, 5%	817007680		RCR07
S2	10-C2		Switch SPDT (Norm/Ratio)	815111001	14	7101
S3	10-E7		Switch DPDT (Suppress)	815111007	14	7201
S4	10-B7		Switch DPDT (Expand)	815111007	14	7201
S5	1-C2		Switch 4D3T (Sens. Input)	815111025	14	7411
S6	10-C9		Switch Asm (Zero Suppress)	B22649G1	31	B22649G1
S7	4, 6-H3		Switch Asm (Time Constant)	B22645G1	31	B22645G1
S8	1-D4, C6		Switch Asm (Sensitivity)	B22651G1	31	B22651G1

REAR PANEL ASSEMBLY D42038G1 397EO

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
A13	12-D2		Connector, Volt Select, Fused	812120009	16	6J1
C1	12-F5		Capacitor, 1μF, 35V, 10%, Ta	811504028	48	196D-105X9035HA1
E1	12-D3		Terminal, Crimp #6	812125808	66	323986
E2	12-D3		Terminal Lug	812800300	47	1410-4
F1	12-C2		Fuse, 3/4A Slo Blo	815183017	69	323750
J10	1-B1		Connector BNC	812130110	19	30355-1
J11	12-E10		Connector 3 Pin XLR	812123002	11	XLR-4-12C
J12	8-C2		Connector BNC	812130110	19	30355-1
J13	10-G8		Connector BNC	812130110	19	30355-1
J14	1-D1		Connector BNC	812130110	19	30355-1
P13	12-B6		Connector Block 3 pos	812122503	81	65486-003
P14	12-D8		Connector Block 3 Pos	812122503	81	65486-003
P15	12-F6		Connector Block 3 Pos	812122503	81	65486-003
P16	12-E9		Connector Block 4 Pos	812122504	81	65486-004
Q1	12-B6		Transistor 2N4918	818204918		2N4918
Q2	12-D8		Transistor 2N4921	818204921		2N4921
U1	12-F6		I.C. LM309K	816400020	26	LM309K

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
A1	A5	C3	P.C. Assembly	C32129G1	31	C32129G1
A1-A1	C5	B3	Module, Multi Function	816400033		AD433J
C1	D2	B2	Capacitor, .01μF, 500V, 20%, Cer	811570019	48	5GAS-S10
C2	E2	B2	Capacitor, .01μF, 500V, 20%, Cer	811570019	48	5GAS-S10
CR1	C2	C5	Diode	A86003P1	31	A86003P1
CR2	C2	B5	Diode	A86003P1	31	A86003P1
			RESISTOR			
R1	C2	B5	10K, 25 turn (POT)	817806103	7	3299X-1-103
R2	C3	C4	1.96K *	817211196		RN60D
R3	C3	C4	1.96K *	817211196		RN60D
R4	D4	B4	10K, 25 turn (POT)	817806103	7	3299X-1-103
R5	E4	C4	1.47K, *	817211147		RN60D
R6	C7	C2	9.003K **	817261114	63	RE 1/4 C-1 9.003K
R7	D7	C2	1.000K **	817261042	63	REA 1/8, 1.0K C-1
R8	C2	C5	2.2K	817007222		RC07
U1	C2	C5	Op Amp 741C	816400011		741C
U2	C3	C4	Op Amp 741C	816400011		741C
J201	C1	C3	Connector BNC	812130110	19	30355-1
P1	D1	B5	Connector	812122503	81	65486-003
R201	D4	C3	Resistor (POT) 5K	817900001	84	8146-R5K-L.25

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			CAPACITORS			
C1	B3	B5	15μF, 20V, 10%, Sol Ta	811504020	48	186D-156X9020KA1
C2	B3	C5	15μF, 20V, 10%, Sol Ta	811504020	48	186D-156X9020KA1
C3	B3	B5	15μF, 20V, 10%, Sol Ta	811504020	48	186D-156X9020KA1
			DIODES			
CR1	E2	B3	IN4148	818100003		IN4148
CR2	E2	B3	IN4148	818100003		IN4148
CR3	E4	B3	IN4148	818100003		IN4148
CR4	E4	B3	IN4148	818100003		IN4148
CR5	E4	B3	IN4148	818100003		IN4148
CR6	E6	B2	IN4148	818100003		IN4148
CR7	E7	B2	IN4148	818100003		IN4148
CR8	D6	B5	IN4148	818100003		IN4148
CR9	D6	B5	IN4148	818100003		IN4148
CR10	B7	C4	IN4148	818100003		IN4148
CR11	C7	B5	IN4148	818100003		IN4148
J1	B2	B5	Connector, 14 Pin Dip Socket	812129113	101	CA-14S-10SD
K1	E6	B2	Relay	814500014	24	1A5AHH
K2	E6	B2	Relay	814500014	24	1A5AHH
K3	B6	C4	Relay	814500014	24	1A5AHH
K4	B7	C4	Relay	814500014	24	1A5AHH
			TRANSISTORS			
Q1	D4	C3	2N3904	818203904		2N3904
Q2	D4	B3	2N3904	818203904		2N3904
Q3	D5	C2	A86013P3	A86013P3	31	A86013P3
Q4	E5	B2	2N3904	818203904		2N3904
Q5	E6	B2	2N3904	818203904		2N3904
Q6	B6	C4	2N3904	818203904		2N3904
Q7	B6	C4	2N3904	818203904		2N3904
Q8	C6	C4	2N3904	818203904		2N3904
Q9	C7	C3	2N3904	818203904		2N3904
Q10	B7	C2	TIS-75	818700009	55	TIS-75

TABLE 6.2 REPLACEABLE PARTS

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			TRANSISTORS (continued)			
Q11	B8	C3	TIS-75	818700009	55	TIS-75
Q12	B8	C3	TIS-75	818700009	55	TIS-75
Q13	D7	C5	2N3906	818203906		2N3906
Q14	C7	C2	2N3906	818203906		2N3906
Q15	C8	C3	2N3906	818203906		2N3906
Q16	C8	C3	2N3906	818203906		2N3906
Q17	C9	C5	TIS-75	818700009	55	TIS-75
Q18	D8	C2	2N3904	818203904		2N3904
Q19	C8	C3	2N3904	818203904		2N3904
Q20	C9	C3	2N3904	818203904		2N3904
Q21	D9	C5	2N3904	818203904		2N3904
			RESISTORS			
			All resistors unless otherwise designated are 1/4W, 5%, Comp * 1/8W, 1%, Metflm ** 1/8W, 0.1%, Metflm ***1/10W, 1%, Temp Stable, Metflm			
R1	B3	B5	10 ohm			
R2	B2	C5	1K	817007102		RC07
R3	C2	B5	47K	817007473		RC07
R4	C2	B5	47K	817007473		RC07
R5	C2	B5	47K	817007473		RC07
R6	C3	B5	1M	817007105		RC07
R7	C3	C3	1M	817007105		RC07
R8	C3	C3	1M	817007105		RC07
R9	C3	B4	1M	817007105		RC07
R10	D3	C3	10K	817007103		RC07
R11	D3	C3	82K	817007823		RC07
R12	D4	B2	22K	817007223		RC07
R13	D3	B3	47K	817007473		RC07
R14	D3	B3	2.7K	817007272		RC07
R15	E3	B3	2.7K	817007272		RC07

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			RESISTORS (continued)			
R16	E3	B3	2.7K	817007272		RC07
R17	F3	B2	47K	817007473		RC07
R18	E4	B3	82K	817007823		RC07
R19	E5	B2	12K	817007123		RC07
R20	E6	B2	22K	817007223		RC07
R21	D6	B5	82K	817007823		RC07
R22	B6	B5	12K	817007123		RC07
R23	C6	B5	12K	817007123		RC07
R24	C6	B5	12K	817007123		RC07
R25	C7	C4	12K	817007123		RC07
R26	C7	B5	12K	817007123		RC07
R27	C7	C2	12K	817007123		RC07
R28	C8	C2	12K	817007123		RC07
R29	C8	C3	12K	817007123		RC07
R30	C9	C5	2.2M	817007225		RC07
R31	B8	C2	2.2M	817007225		RC07
R32	B8	C3	2.2M	817007225		RC07
R33	B8	C3	2.2M	817007225		RC07
R34	D8	C2	12K	817007123		RC07
R35	D8	C2	12K	817007123		RC07
R36	D9	C3	12K	817007123		RC07
R37	D9	C5	12K	817007123		RC07
R38	D4	B3	22K	817007223		RC07
R39	D4	B3	220 ohm	817007221		RC07
U1	D5	B2	I.C. CD4011BE	816374011		CD4011BE
U2	C5	B4	I.C. CD4028BE	816374028		CD4028BE
U3	B6	B4	I.C. CD4011BE	816374011		CD4011BE

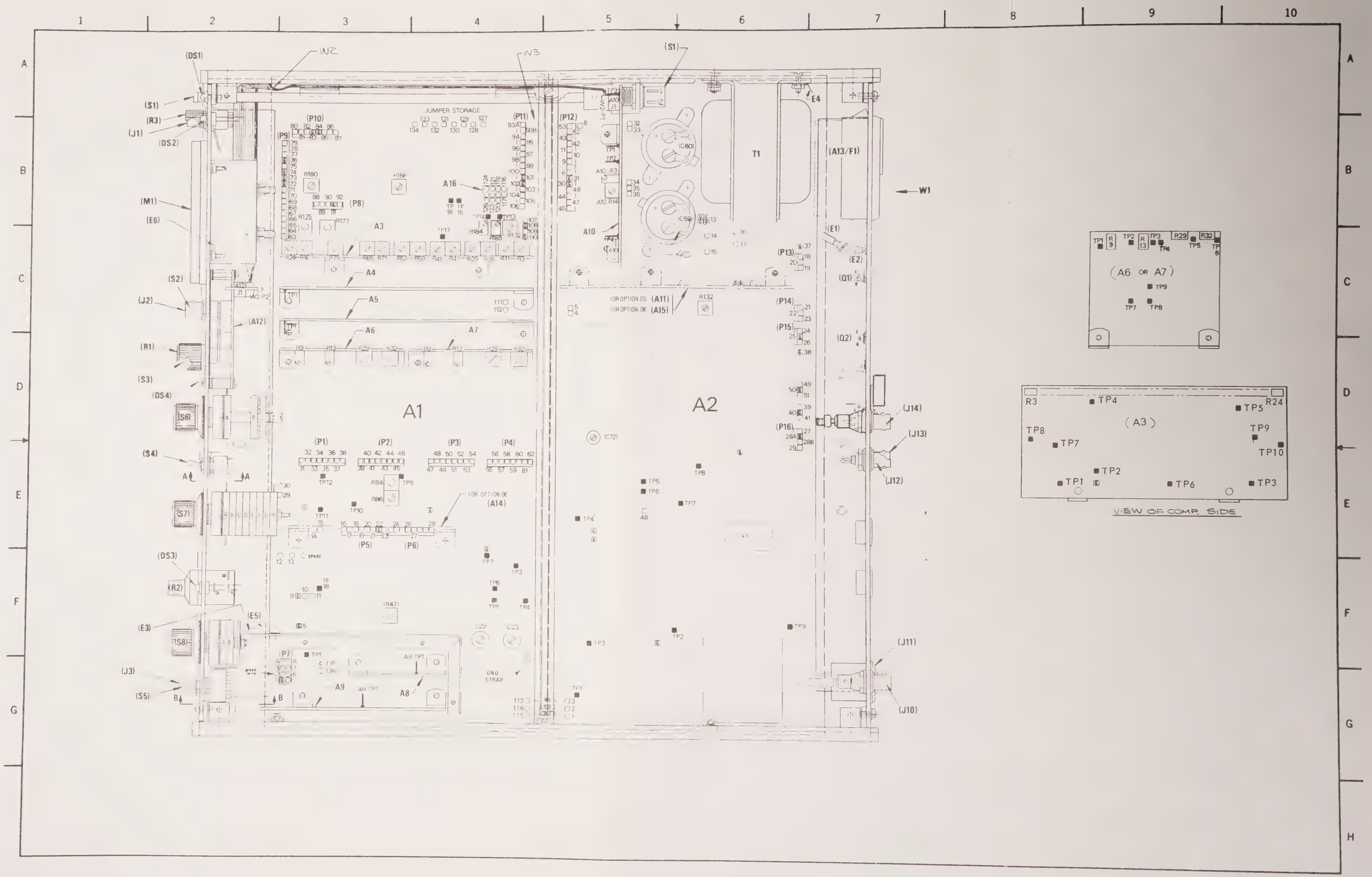
REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			CAPACITORS			
C1	E4	D4	15μF, 20V, 10%, Tant	811504020	48	196D-156X9020KA1
C2	E3	C5	.01μF, 500V, 20%, Cer	811570019	48	5GAS-S10
CR1	D4	D4	Diode IN4148	818100003		IN4148
J1	C6	C3	Connector, 14 pin Dip Socket	812129113	101	CA-14S-10SD
J2	B2	D6	Connector, 26 pin Straight Cont	812127022	103	609-2622M
Q1	E5	D4	Transistor 2N3904	818203904		2N3904
			RESISTORS			
R2	D4	D3	56K	817007563		RC07
R3	D4	D4	56K	817007563		RC07
R4	D5	D4	56K	817007563		RC07
R5	E5	D4	56K	817007563		RC07
R7	E4	D4	1K	817007102		RC07
U1	D3	C5	I.C. Hex Buffer	817374050		CD4050BE
U2	E3	D5	I.C. CD4093BE	816374093		CD4093BE

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
A1	C2	B2	Amplifier, LOG/Antilog AD759N	816400069	5	AD759N
			CAPACITORS			
C1	B3	B4	100pF, 1000V, 20%, Cer	811572011	48	10TS-T10
C2	B4	C4	.01μF, 500V, 20% Cer	811570019	48	5GAS-S10
C3	B4	C3	.01μF, 500V, 20%, Cer	811570019	48	5GAS-S10
C4	C4	B3	100pF, 1000V, 30%, Cer	811572011	48	10TS-T10
			DIODES			
CR1	B2	C4	IN4005	818100007		IN4005
CR2	B2	C4	IN4005	818100007		IN4005
			RESISTORS			
			All resistors unless otherwise designated are 1/4W, 5%, Comp * 1/8W, 1%, Metflm ** 1/8W, 0.1%, Metflm ***1/10W, 1%, Temp Stable, Metflm			
R1	B2	B5	10K (POT)	817806103	7	3299X-1-103
R2	B2	B4	42.2K *	817212422		RN60D
R3	B2	C4	61.9K *	817212619		RN60D
R4	A3	B4	13.3K *	817212133		RN60D
R5	B3	B4	10K	817007103		RC07
R6	B4	B4	19.6K *	817212196		RN50D
R7	B4	C4	10.000K **	817261048	63	REA 1/8, 10K C-1
R8	B4	C4	10.000K **	817261048	63	REA 1/8, 10K C-1
R9	C5	C4	1.000K **	817261042	63	REA 1/8, 1.0K C-1
R10	C4	C3	3.9K	817007392		RC07
R11	C4	C3	9.003K **	817261114	63	RE 1/4, C-1 9.003K
R12	C3	C3	19.6K *	817212196		RN60D
R13	C3	B3	1K (POT)	817806102	7	3299X-1-102
R14	C1	B2	100K *	817213100		RN60D
U1	B3	B4	I.C. LM301A	A86050P4	31	A86050P4
U2	C4	C4	I.C. LM301A	A86050P4	31	A86050P4

CODE LIST OF MANUFACTURERS

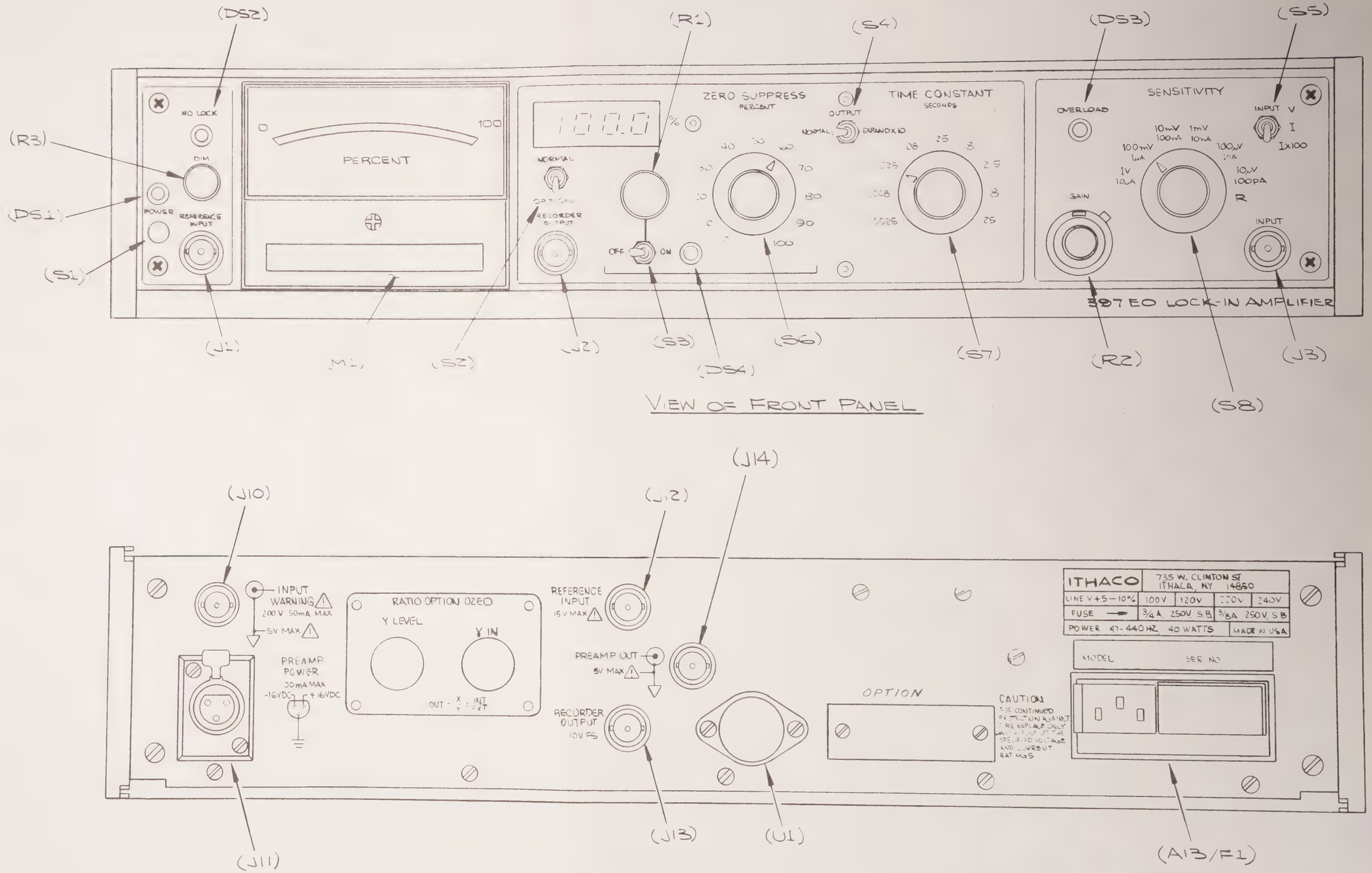
1	Aerovox
2	Alco Electronic Prod
3	Allen Bradley
4	Amphenol Connector
5	Analog Devices
6	Belden
7	Bourns
8	Buckeye Stamping
9	Bussman Mfg
10	Cambion
11	Cannon, ITT
12	Centralab
13	Cinch Mfg
14	C & K Components
15	Continental– Wirt Elec
16	Corcom
17	Cornell Dubilier Elec
18	CTS
19	Dage Electric
20	Delevan Electronics
21	Dresser Systems
22	Electrocube
23	Electro Motive Mfg
24	Electronics Applications
25	Erie Technological Products
26	Fairchield Semiconductor
27	Federal Screw Prod
28	General Electric
29	Helipot
30	Heyman Mfg
31	ITHACO
32	E F Johnson
33	Litronix
34	Marco–Oak Industries
35	Motorola Semiconductor Prod
36	National Semiconductor
37	Ohmite Mfg
38	Paktron
39	Panduit
40	Pomona Electronics
41	Product Components
42	Pyrofilm
43	RCL Electronics
44	Rembrandt
45	Rogan
46	Schauer Mfg
47	H H Smith
48	Sprague Electric
49	Spectrol Electronics
50	Stancor
51	D M Steward Mfg
52	Switchcraft
53	Teledyne Semiconductor
54	Teledyne Western Wire and Cable
55	Texas Instruments
56	Thermalloy
57	TRW
58	United Transformer
59	Useco
60	Vactec
61	Winchester Electronic
62	Vishay
63	ACI
64	IRC
65	EAL
66	AMP
67	Clarostat Mfg
68	Gould Inc
69	Littlefuse Inc
70	General Illumination
71	Signetrics
72	Semiconductor Cir
73	Statek
74	Bendix
75	Burndy
76	American Handle Sales
77	Varo Semiconductor
78	Dialco
79	Elmenco
80	Amp Incorporated
81	Berg
82	Comp Corp
83	Hewlett–Packard
84	Beckman Helipot
85	Raytheon
86	Intersil
87	A H & H
88	ADC Products
89	Scanbe
90	Drake
91	Victoreen
92	Frost
93	Sigma
94	Becon
95	Microswitch
96	Wavetek
97	Electronic Concepts
98	Amelco
99	Mepco
100	RCA
101	Circuit Asm Corp
102	Monsanto
103	Ainsley
104	Keystone Carbon

TABLE 6.3 CODE LIST OF MANUFACTURERS



ITHACO DWG D42040, SH 1, REV L, 9/84

FIGURE 7.1
OVERALL ASSEMBLY
SHEET 1



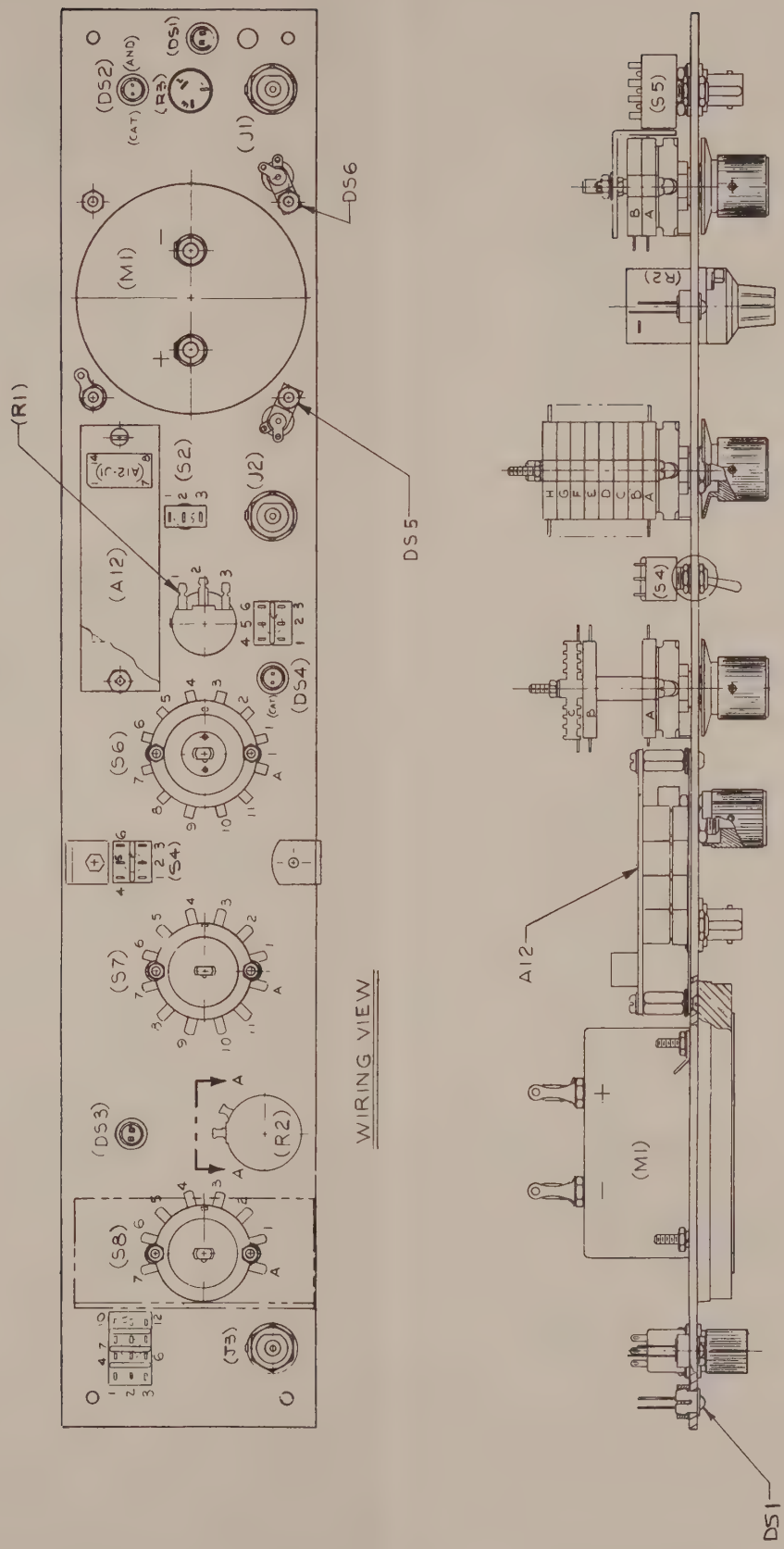
VIEW OF FRONT PANEL

VIEW OF REAR PANEL

(J14)

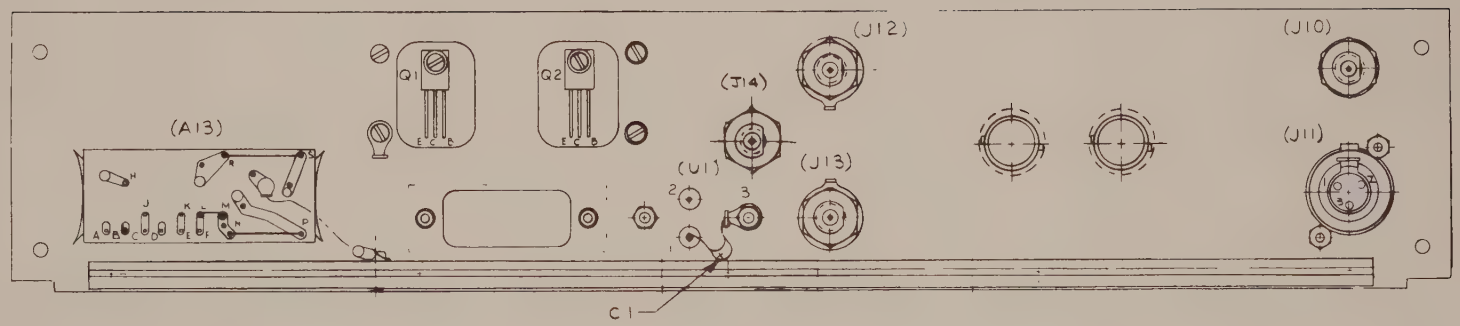
ITHACO DWG D42040, SH 2, REV D, 1/82

FIGURE 7.2
OVERALL ASSEMBLY
SHEET 2



ITHACO DWG D42042, SH 1, REV G, 3/80

FIGURE 7.3 ASSEMBLY – FRONT PANEL



WIRING VIEW

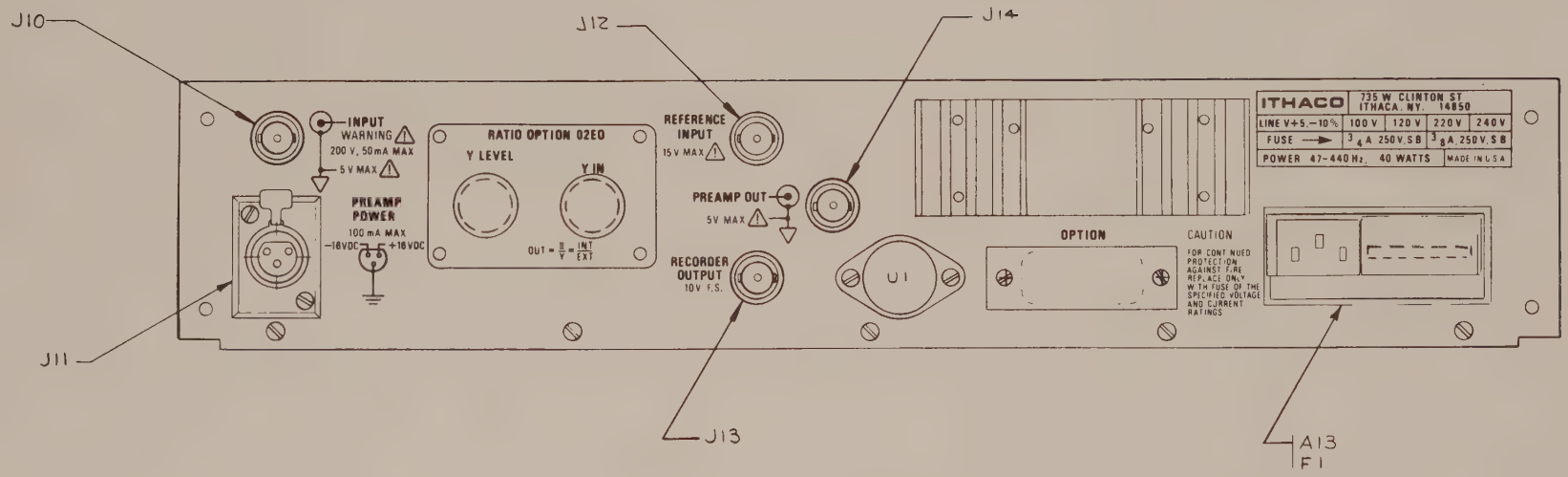


FIGURE 7.4 ASSEMBLY – REAR PANEL

ITHACO DWG D42038, SH 1, REV H, 3/80

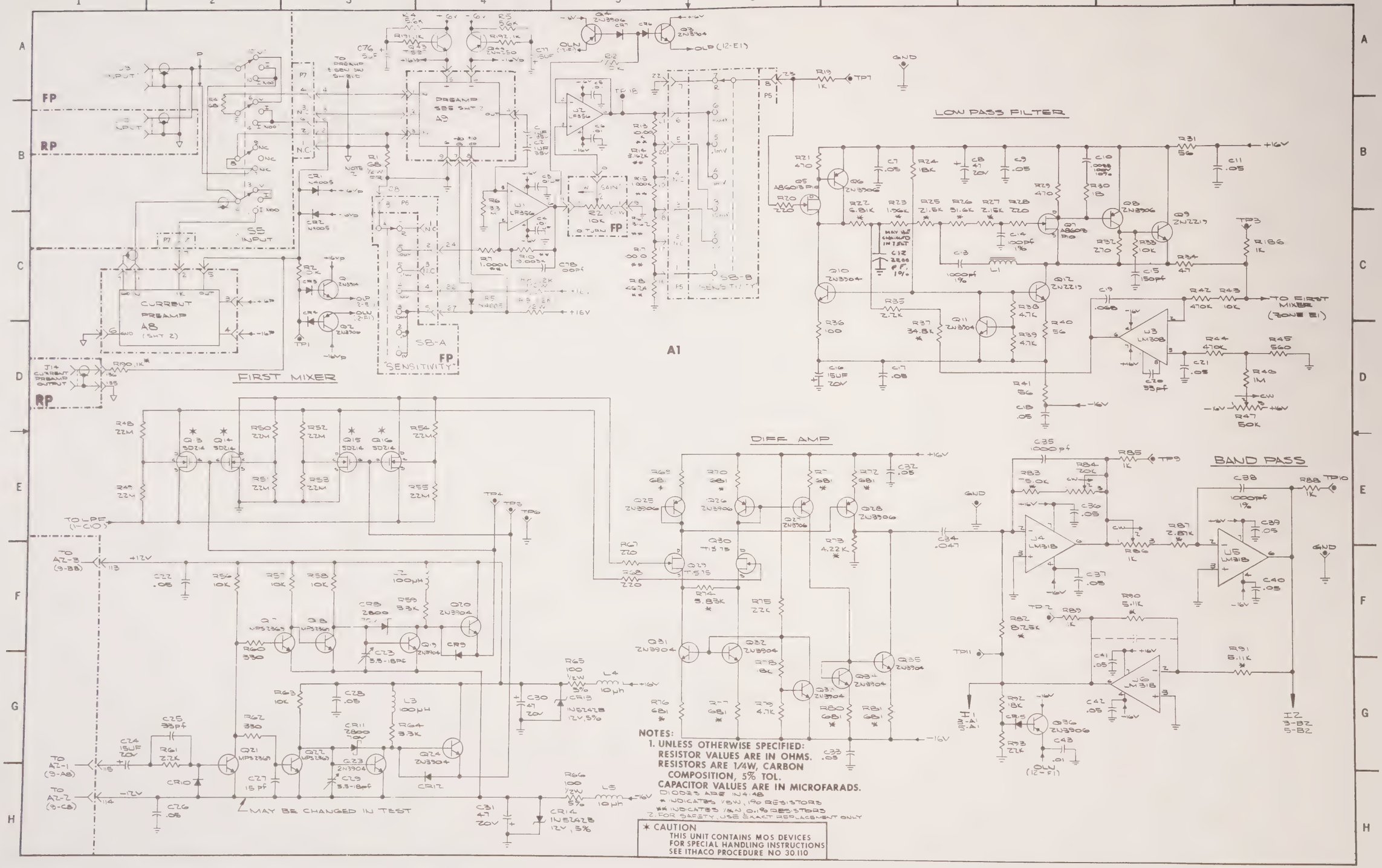
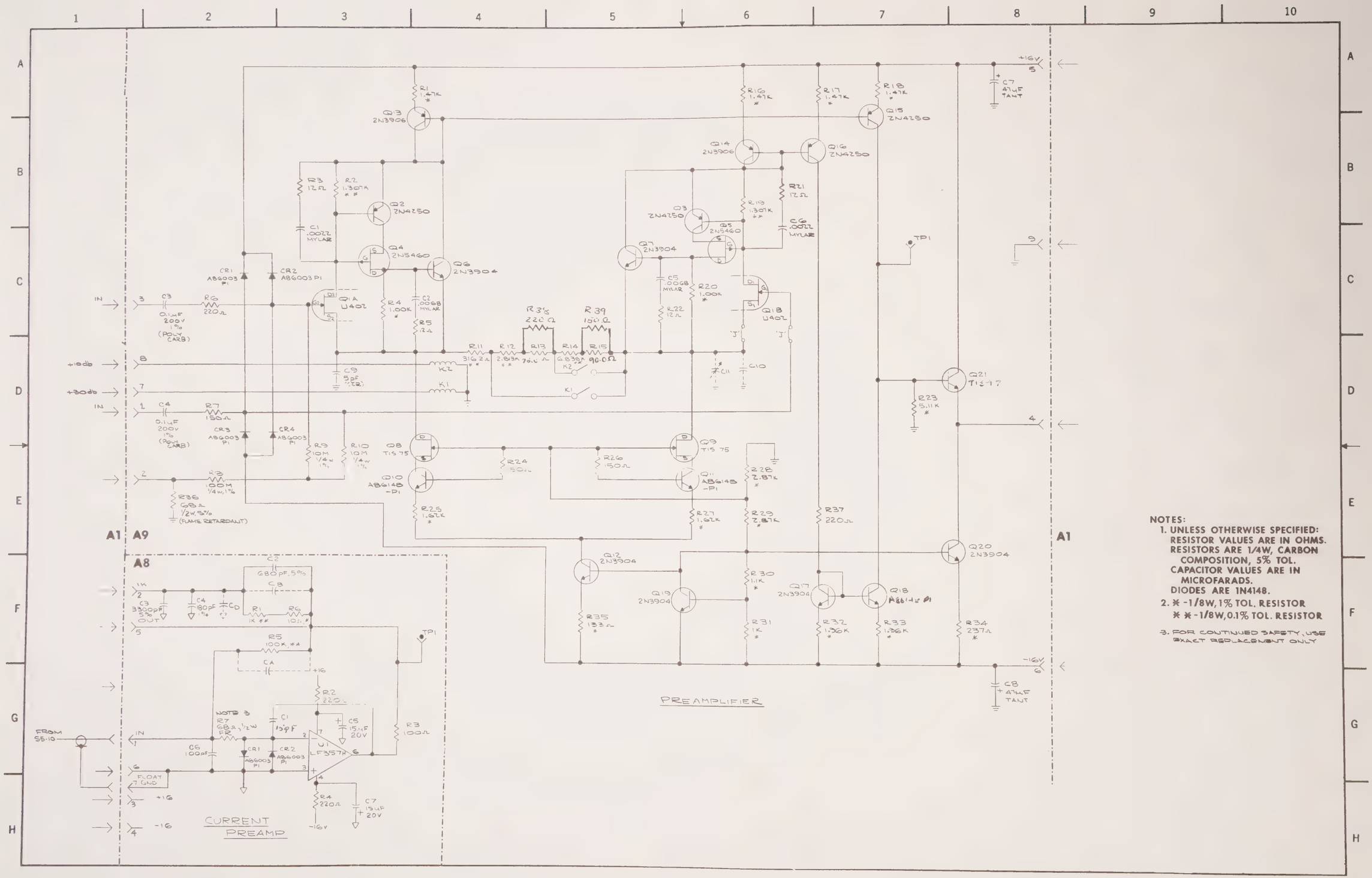
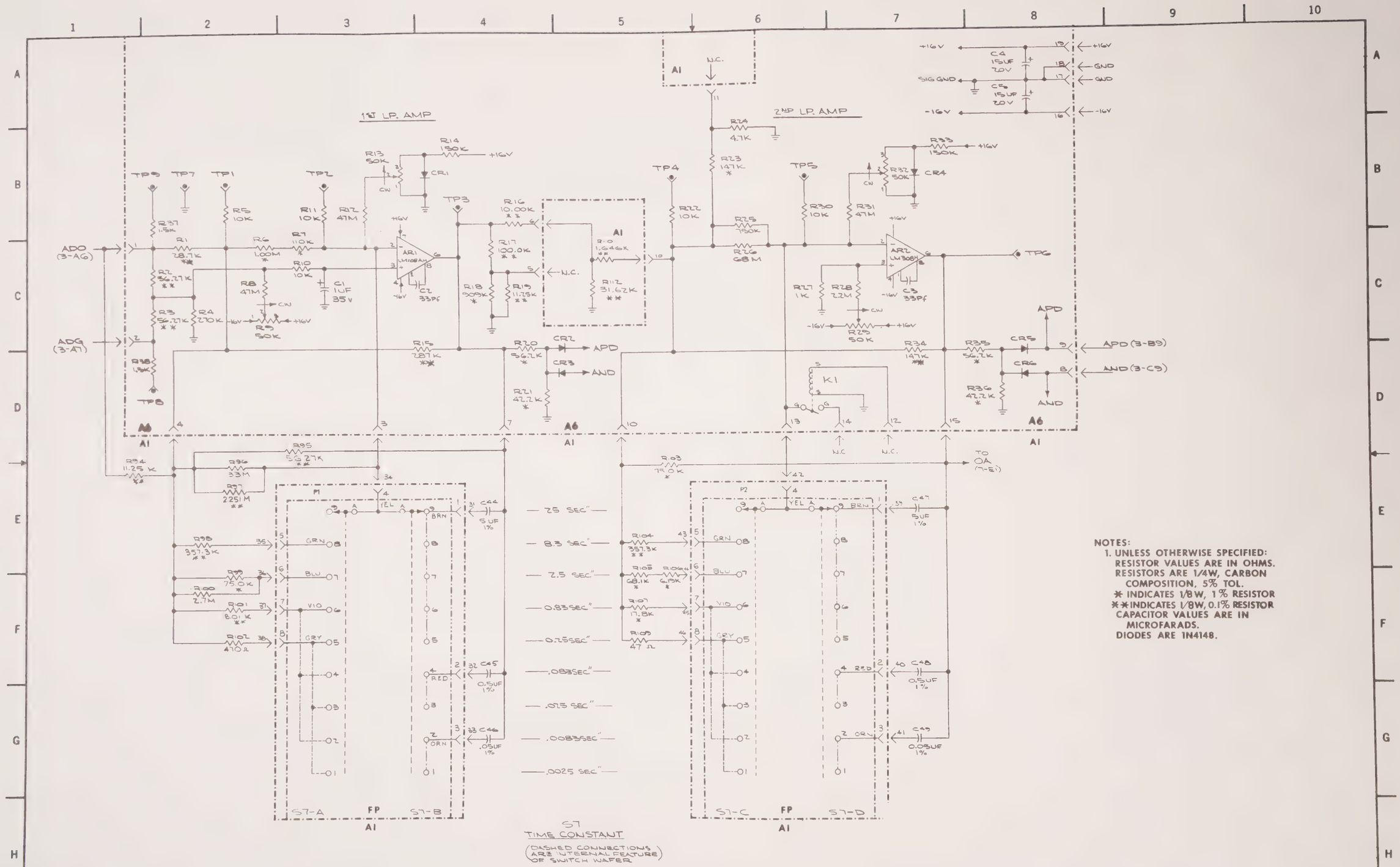


FIGURE 7.5
SCHEMATIC
PREAMP, LP FILTER, 1ST MIXER, DIFF AMP, BANDPASS


PREAMPLIFIER
CURRENT PREAMP
NOTES:
1. UNLESS OTHERWISE SPECIFIED: RESISTOR VALUES ARE IN OHMS. RESISTORS ARE 1/4W, CARBON COMPOSITION, 5% TOL. CAPACITOR VALUES ARE IN MICROFARADS. DIODES ARE 1N4148.
2. * -1/8W, 1% TOL. RESISTOR
** -1/8W, 0.1% TOL. RESISTOR
3. FOR COUTINUED SAFETY, USE EXACT REPLACEMENT ONLY

ITHACO DWG D42026, SH 2, REV E, 10/79

FIGURE 7.6
SCHEMATIC
PREAMPLIFIER AND CURRENT PREAMP



S7
TIME CONSTANT
(DASHED CONNECTIONS ARE INTERNAL FEATURE OF SWITCH WAFER)

NOTES:
1. UNLESS OTHERWISE SPECIFIED:
RESISTOR VALUES ARE IN OHMS.
RESISTORS ARE 1/4W, CARBON COMPOSITION, 5% TOL.
* INDICATES 1/8W, 1% RESISTOR
** INDICATES 1/8W, 0.1% RESISTOR
CAPACITOR VALUES ARE IN MICROFARADS.
DIODES ARE 1N4148.

FIGURE 7.8
SCHEMATIC
LOW PASS AMPLIFIER AND TIME CONSTANT SWITCH

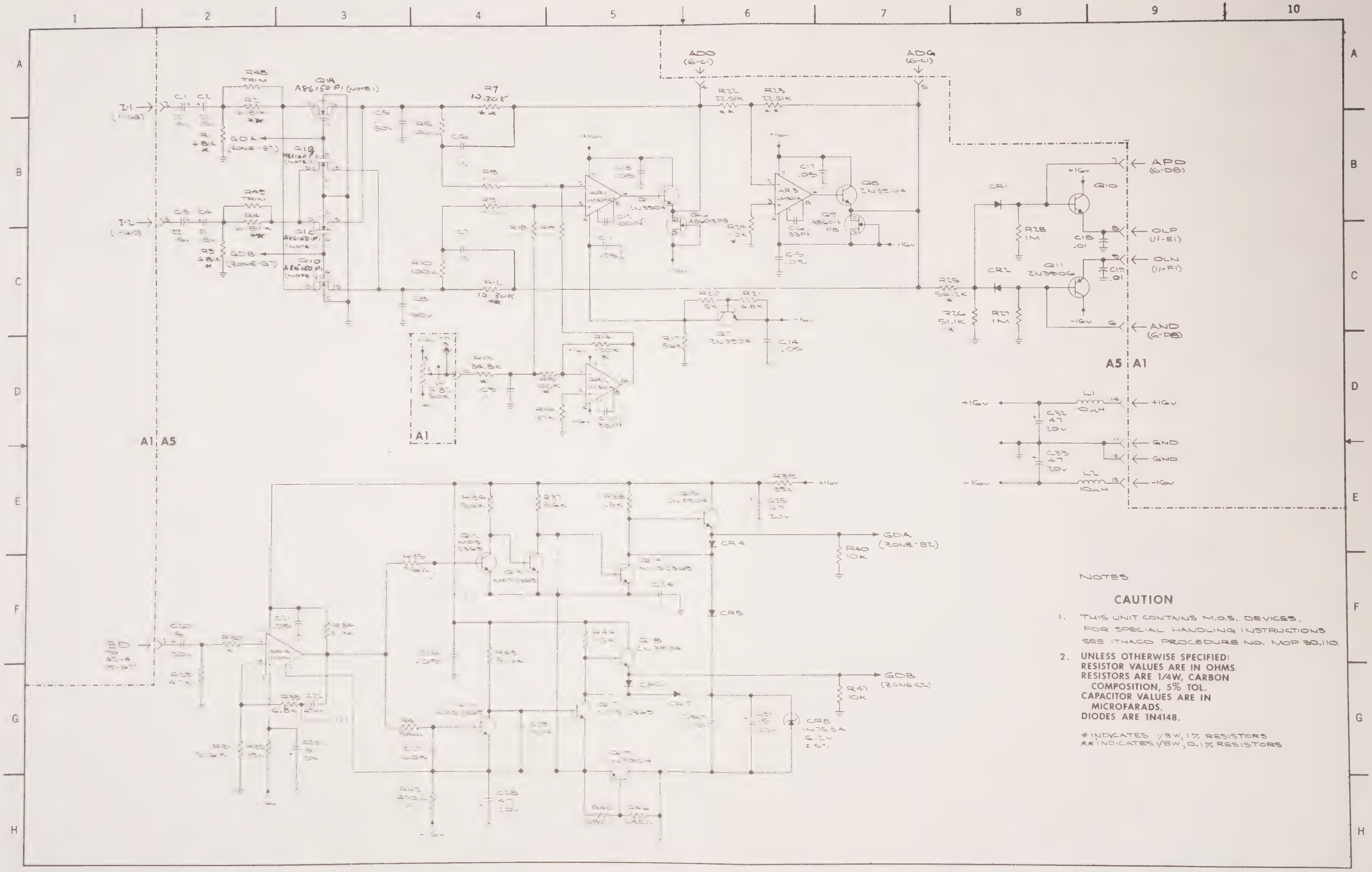


FIGURE 7.9
SCHEMATIC
PHASE SENSITIVE DETECTOR

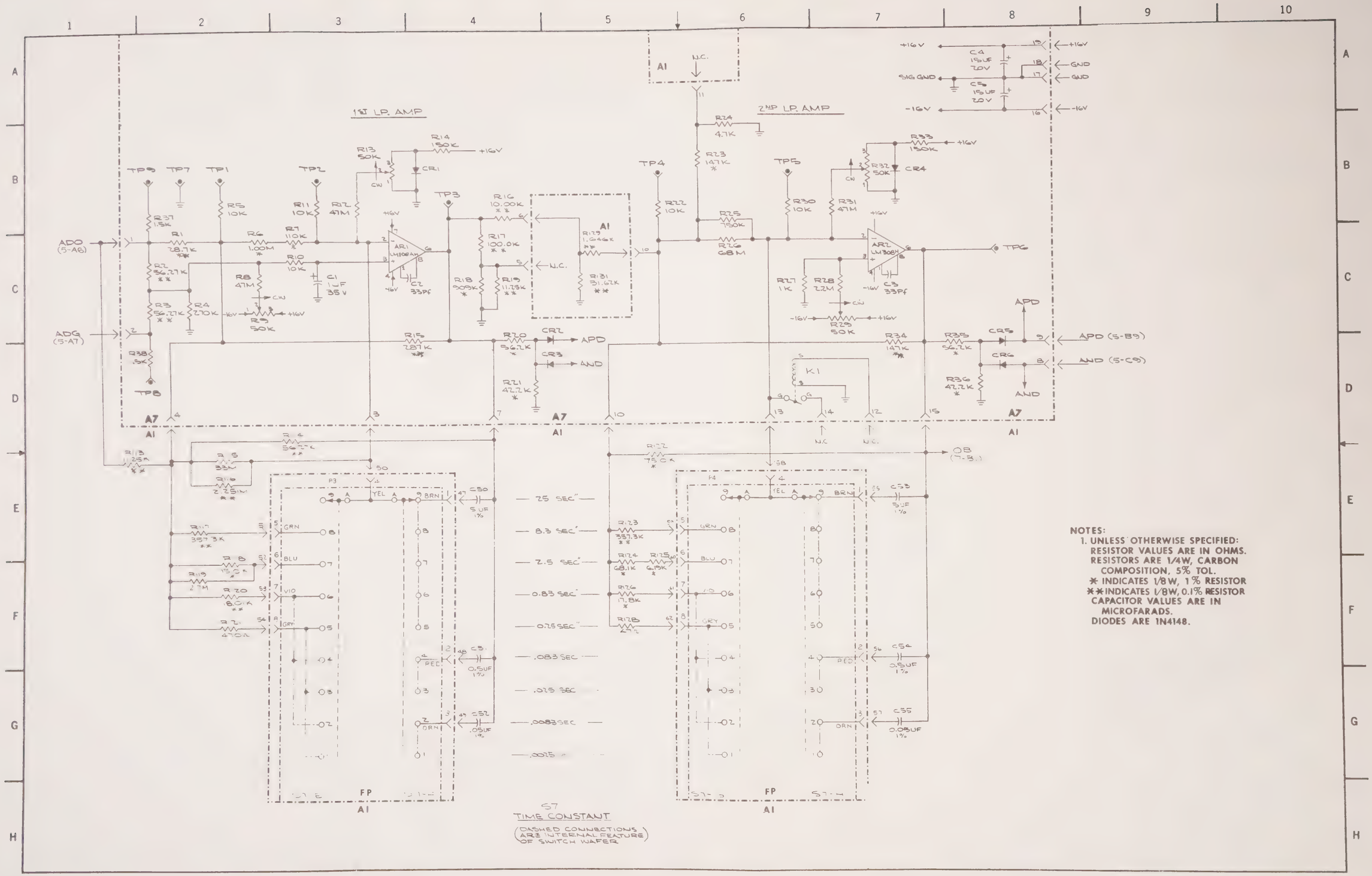
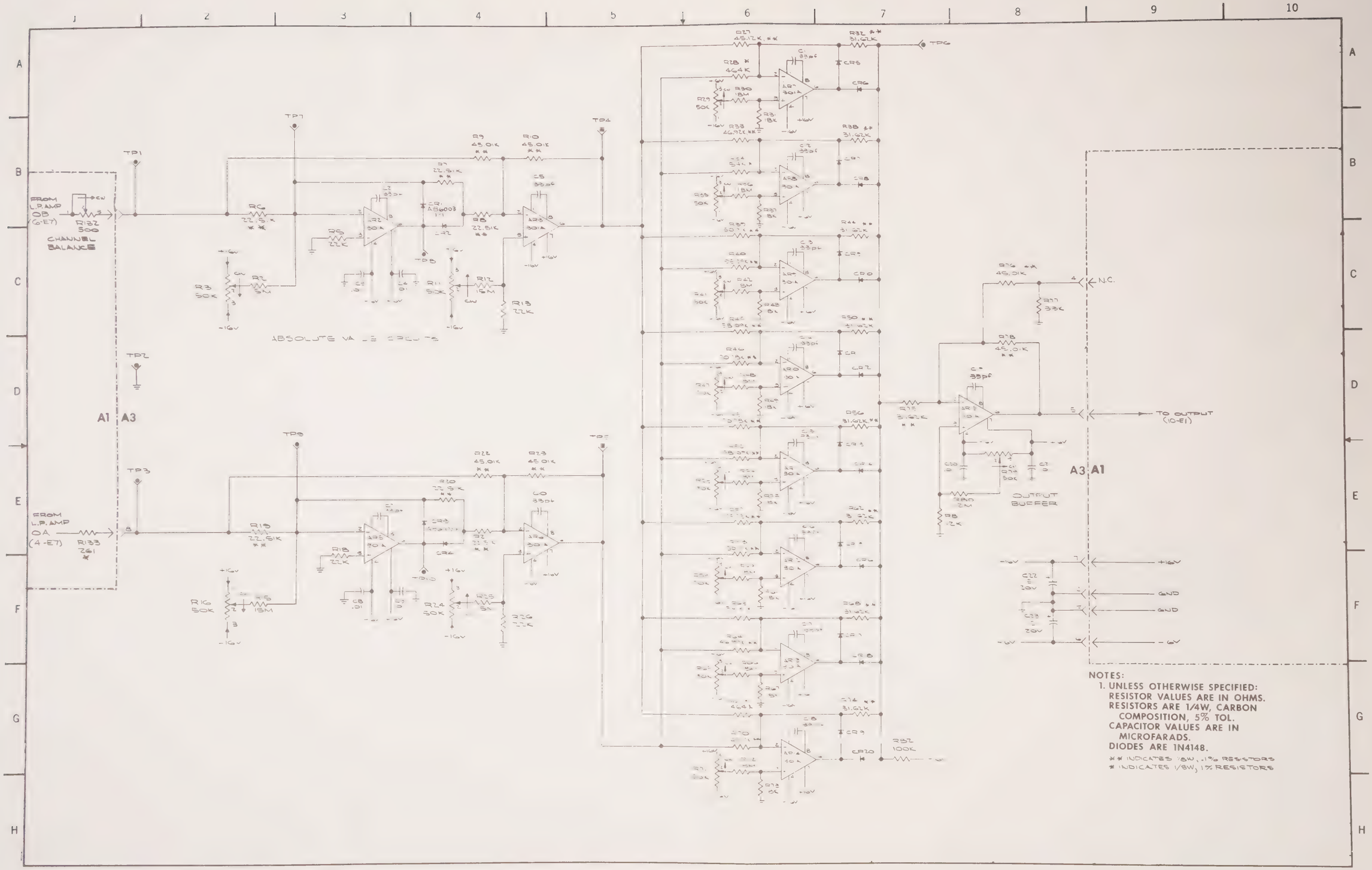


FIGURE 7.10
SCHEMATIC
LOW PASS AMPLIFIER AND TIME CONSTANT SWITCH



NOTES:
1. UNLESS OTHERWISE SPECIFIED:
   RESISTOR VALUES ARE IN OHMS.
   RESISTORS ARE 1/4W, CARBON COMPOSITION, 5% TOL.
   CAPACITOR VALUES ARE IN MICROFARADS.
   DIODES ARE 1N4148.
   ** INDICATES 1/8W, .1% RESISTORS
   * INDICATES 1/8W, 1% RESISTORS

FIGURE 7.11
SCHEMATIC
VECTOR SUMMER

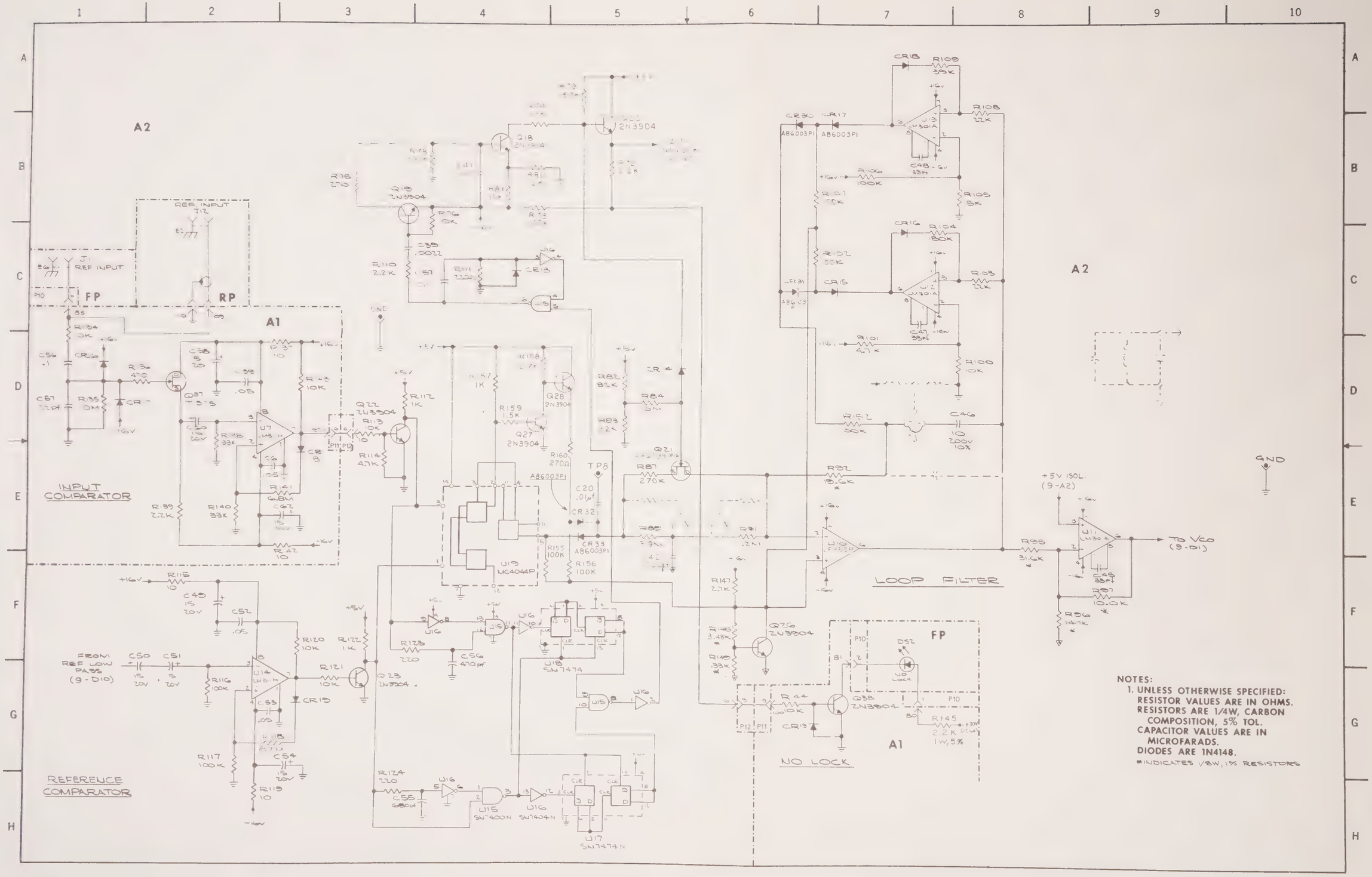


FIGURE 7.12
SCHEMATIC
PLL FILTER

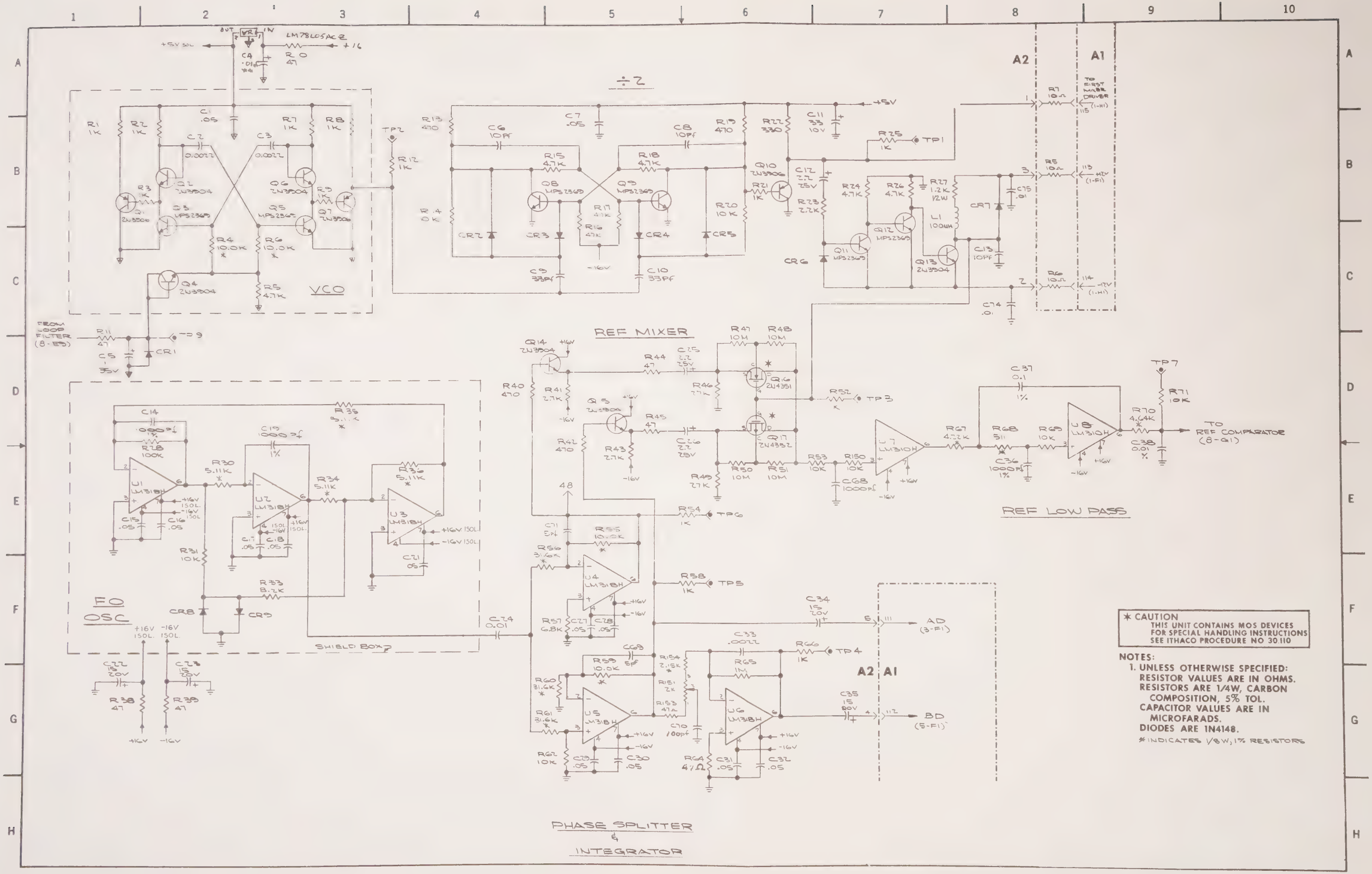
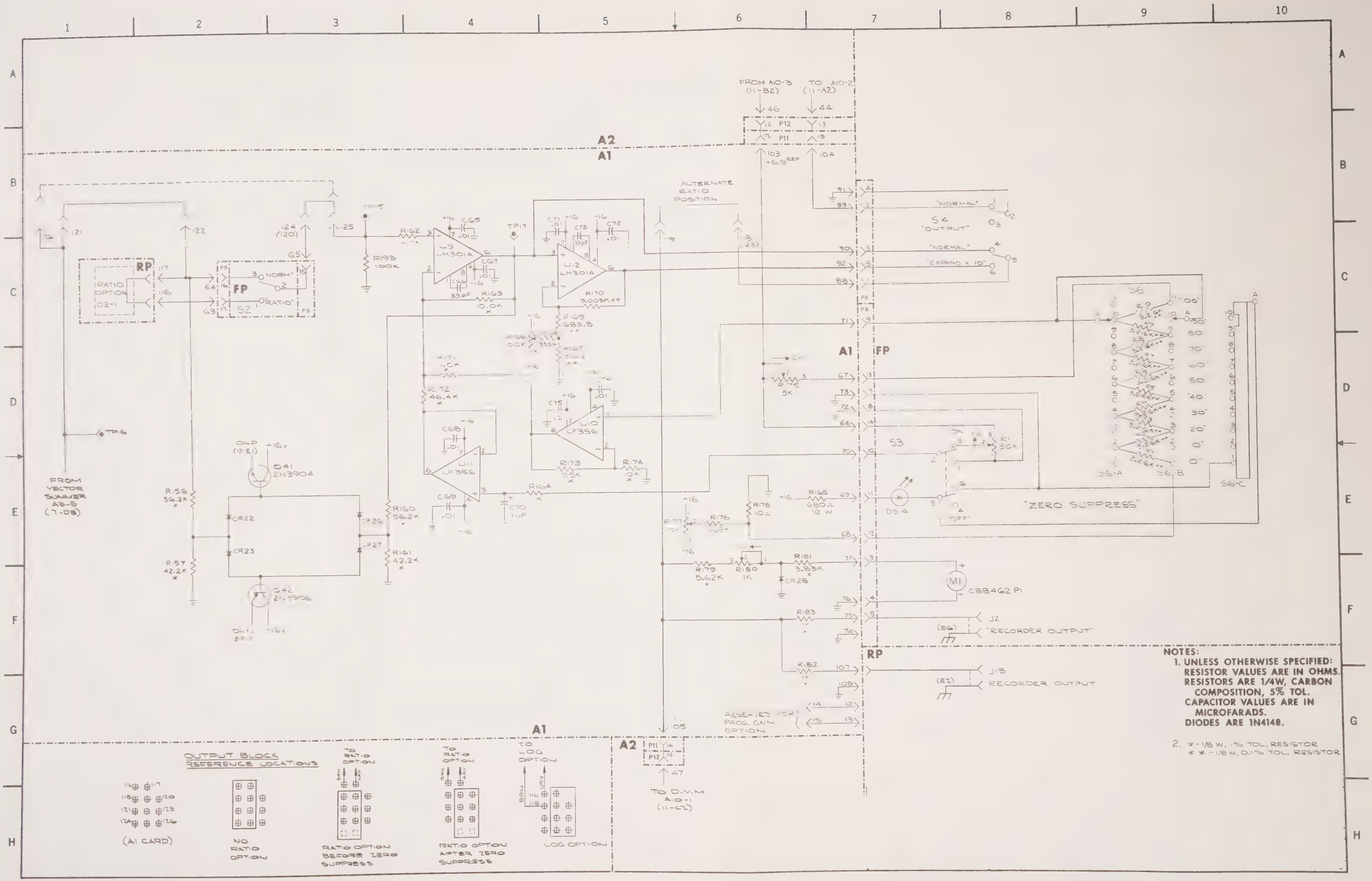
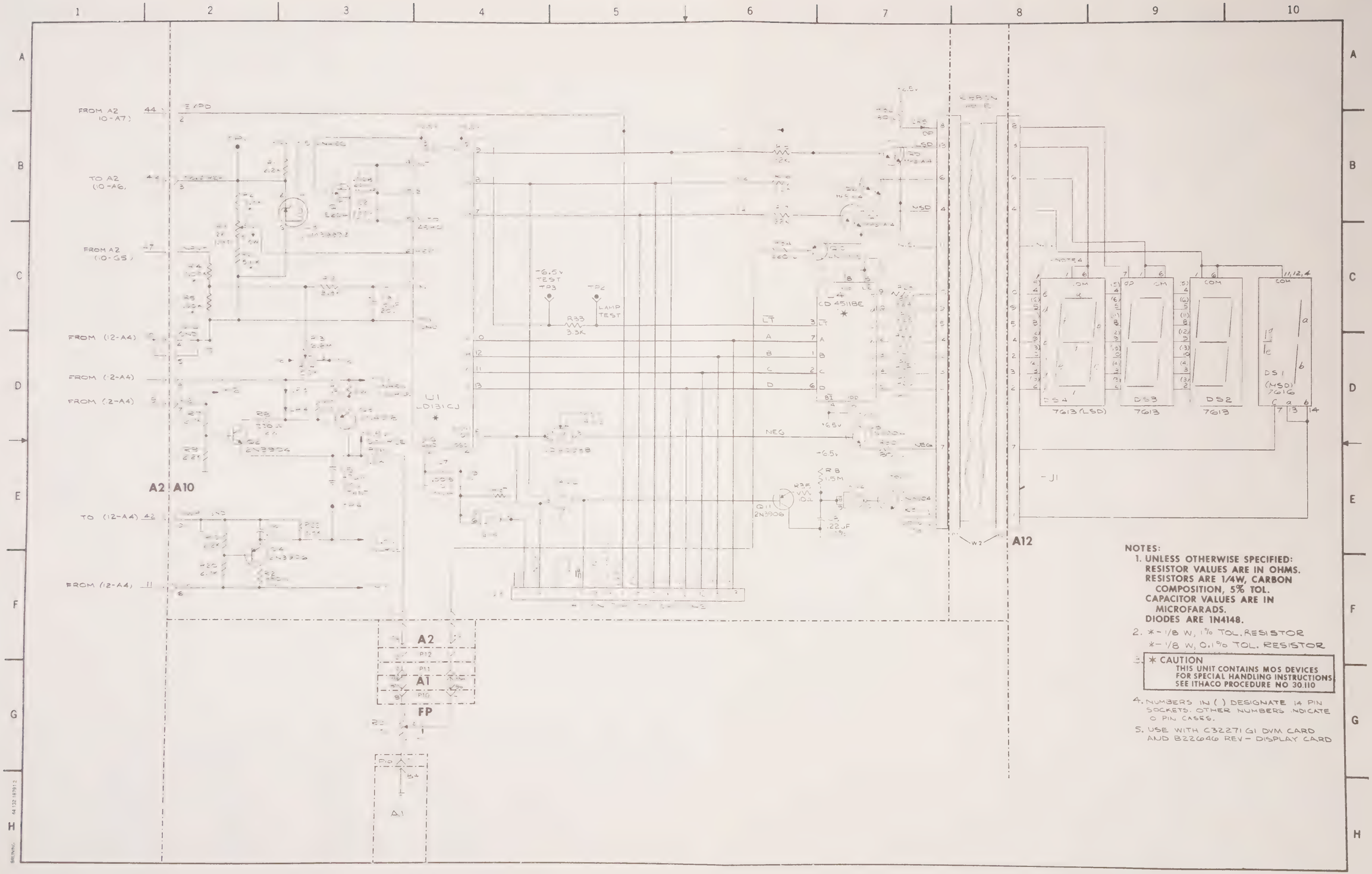


FIGURE 7.13
SCHEMATIC
PLL OSCILLATORS



NOTES:
1. UNLESS OTHERWISE SPECIFIED: RESISTOR VALUES ARE IN OHMS. RESISTORS ARE 1/4W, CARBON COMPOSITION, 5% TOL. CAPACITOR VALUES ARE IN MICROFARADS. DIODES ARE 1N4148.
2. * - 1/8 W, 1% TOL. RESISTOR
   ** - 1/8 W, 0.1% TOL. RESISTOR

FIGURE 7.14
SCHEMATIC
OUTPUT CIRCUITS



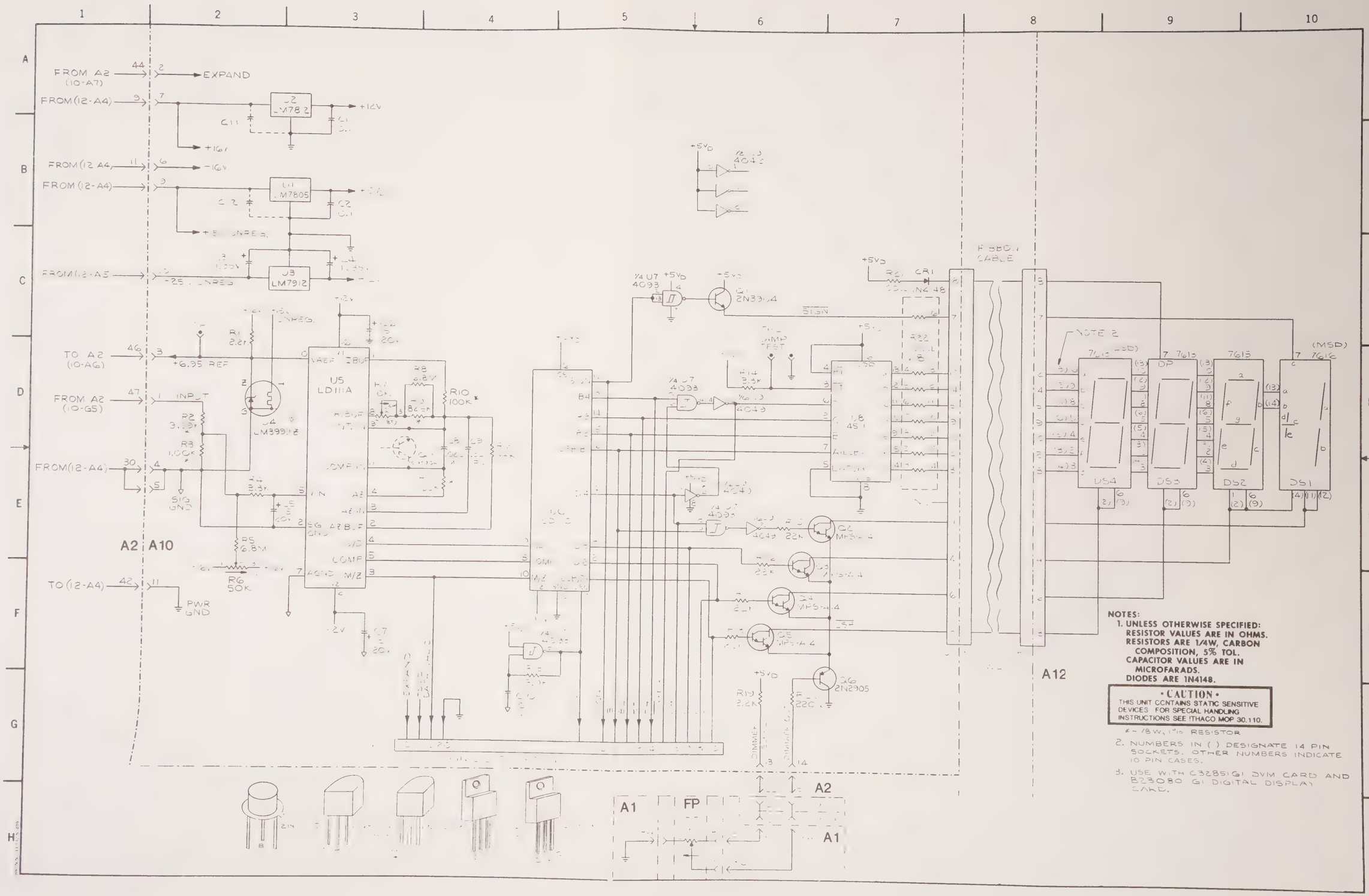
NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   RESISTOR VALUES ARE IN OHMS.
   RESISTORS ARE 1/4W, CARBON COMPOSITION, 5% TOL.
   CAPACITOR VALUES ARE IN MICROFARADS.
   DIODES ARE 1N4148.
2. * - 1/8 W, 1% TOL. RESISTOR
   * - 1/8 W, 0.1% TOL. RESISTOR
3. * CAUTION
   THIS UNIT CONTAINS MOS DEVICES
   FOR SPECIAL HANDLING INSTRUCTIONS
   SEE ITHACO PROCEDURE NO 30.110
4. NUMBERS IN ( ) DESIGNATE 14 PIN SOCKETS. OTHER NUMBERS INDICATE 0 PIN CASES.
5. USE WITH C32271G1 DVM CARD AND B22646 REV - DISPLAY CARD

BRUNING 44132-18912

ITHACO DWG D42026, SH 11, REV F, 4/84

FIGURE 7.15
SCHEMATIC
DVM



ITHACO DWG D42026, SH 11A, 3/84

FIGURE 7.15A
SCHEMATIC
DVM

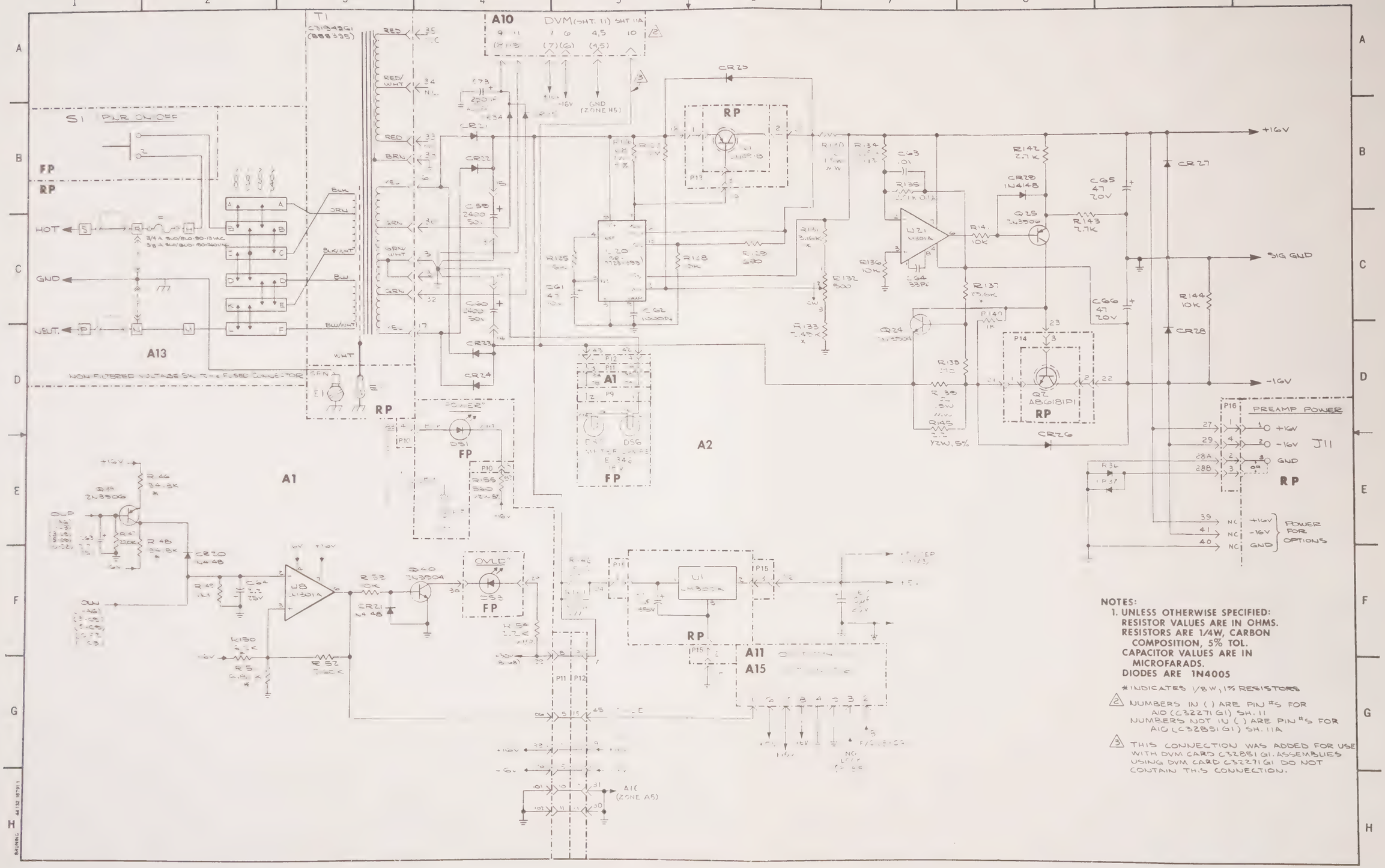
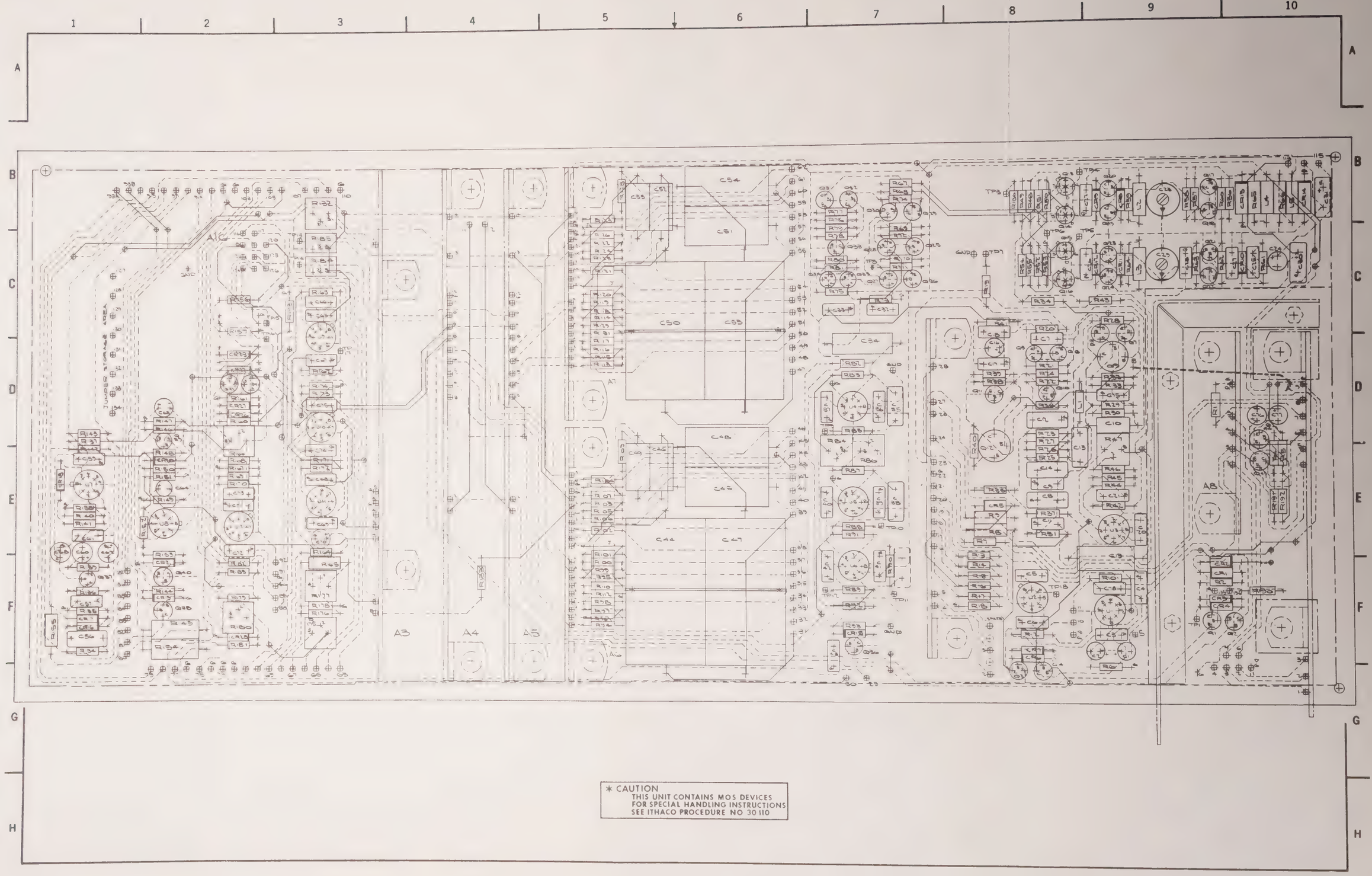
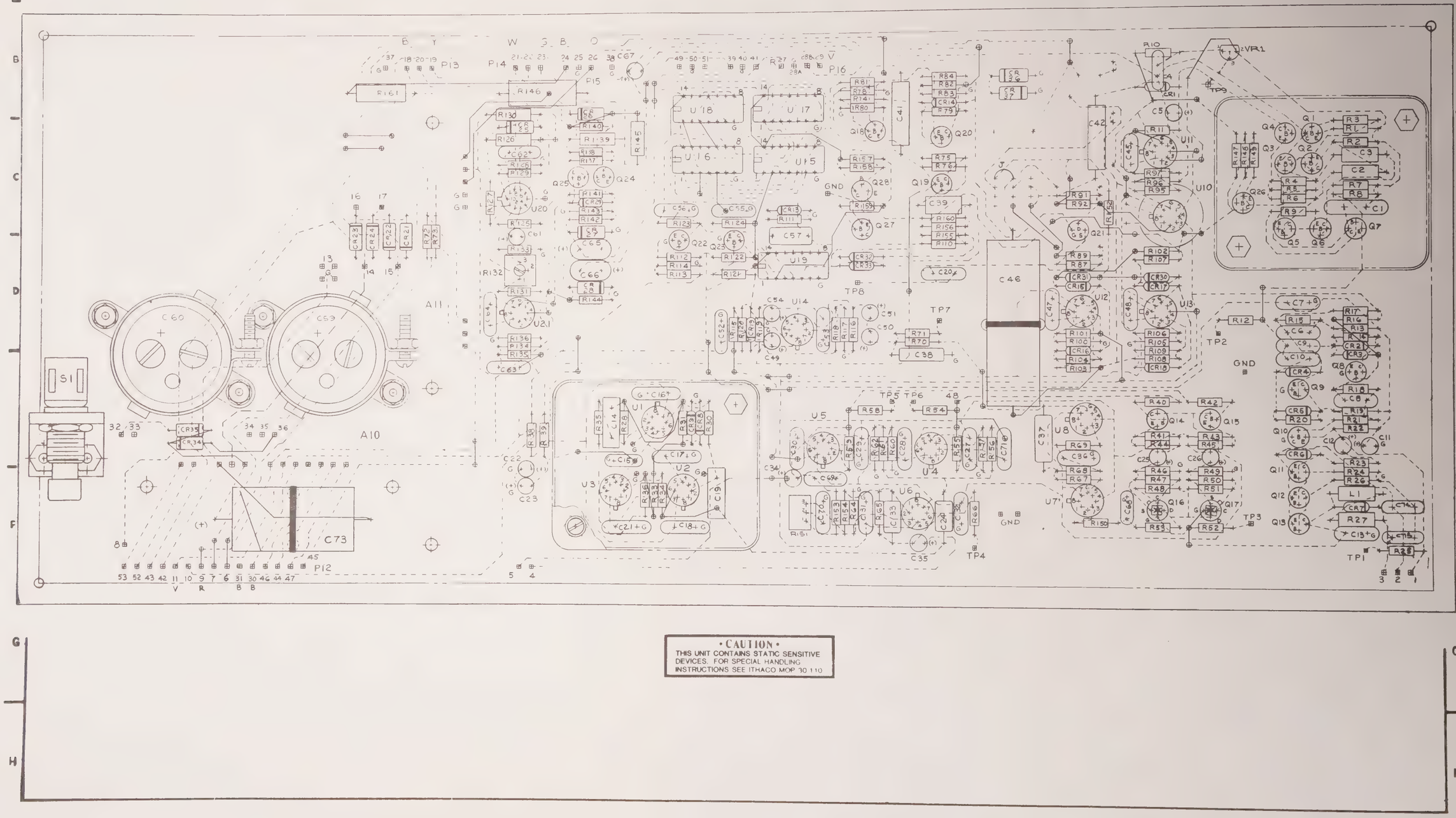


FIGURE 7.16
SCHEMATIC
POWER SUPPLY



ITHACO DWG D42035, SH 1, REV C, 11/78

FIGURE 7.17
ASSEMBLY
A1 MOTHERBOARD


P13
P14
P15
P16
P12
A10
A11
S1
C73
C60
C59
U1
U2
U3
U4
U5
U6
U7
U8
U10
U11
U12
U13
U14
U15
U16
U17
U18
U19
U20
U21
VR1
TP1
TP2
TP3
TP4
TP5
TP6
TP7
TP8
TP9
GND
R10
C5
C42
C46
C41
C39
C38
C20
C54
C49
C51
C50
C35
C34
C37
C36
C68
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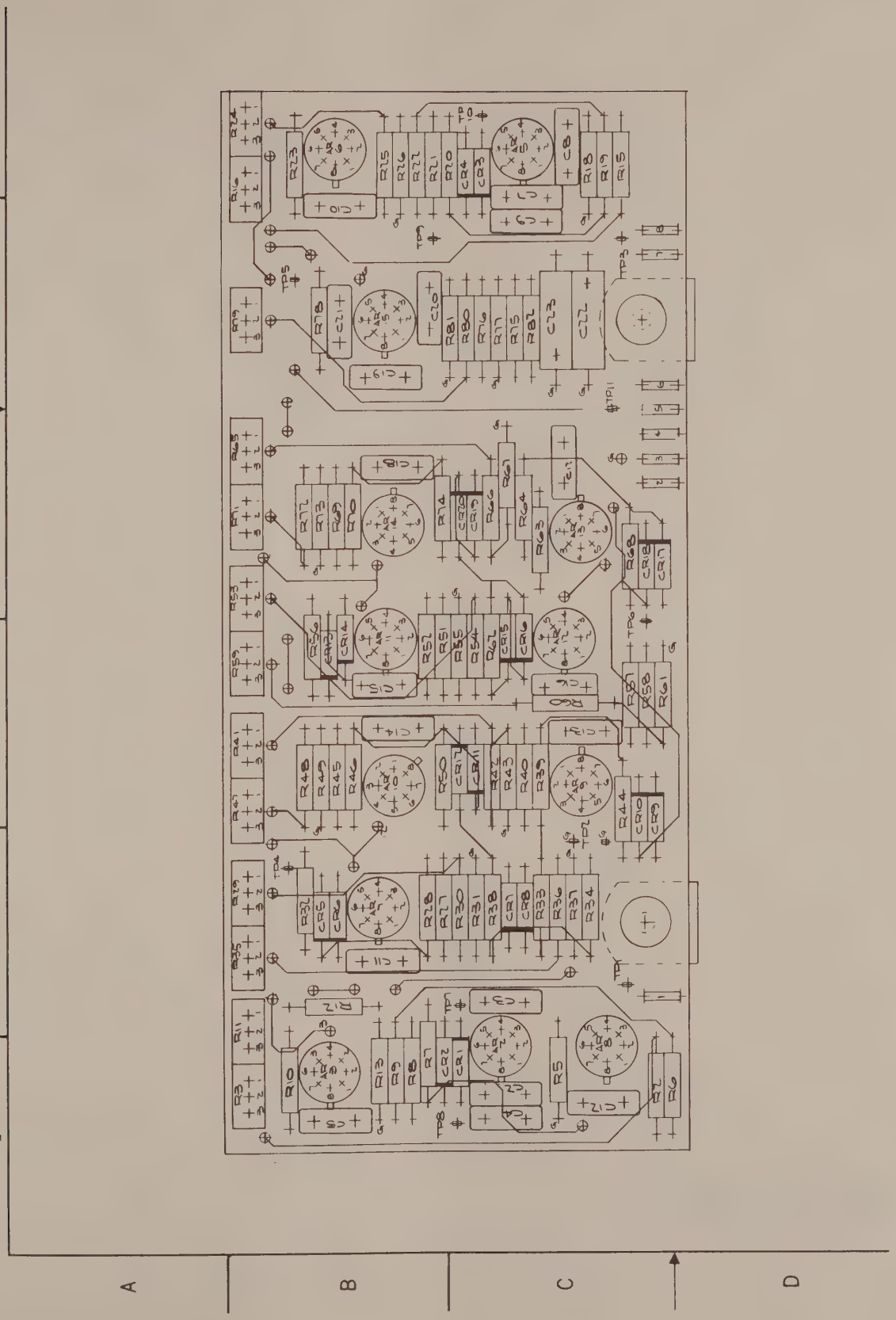
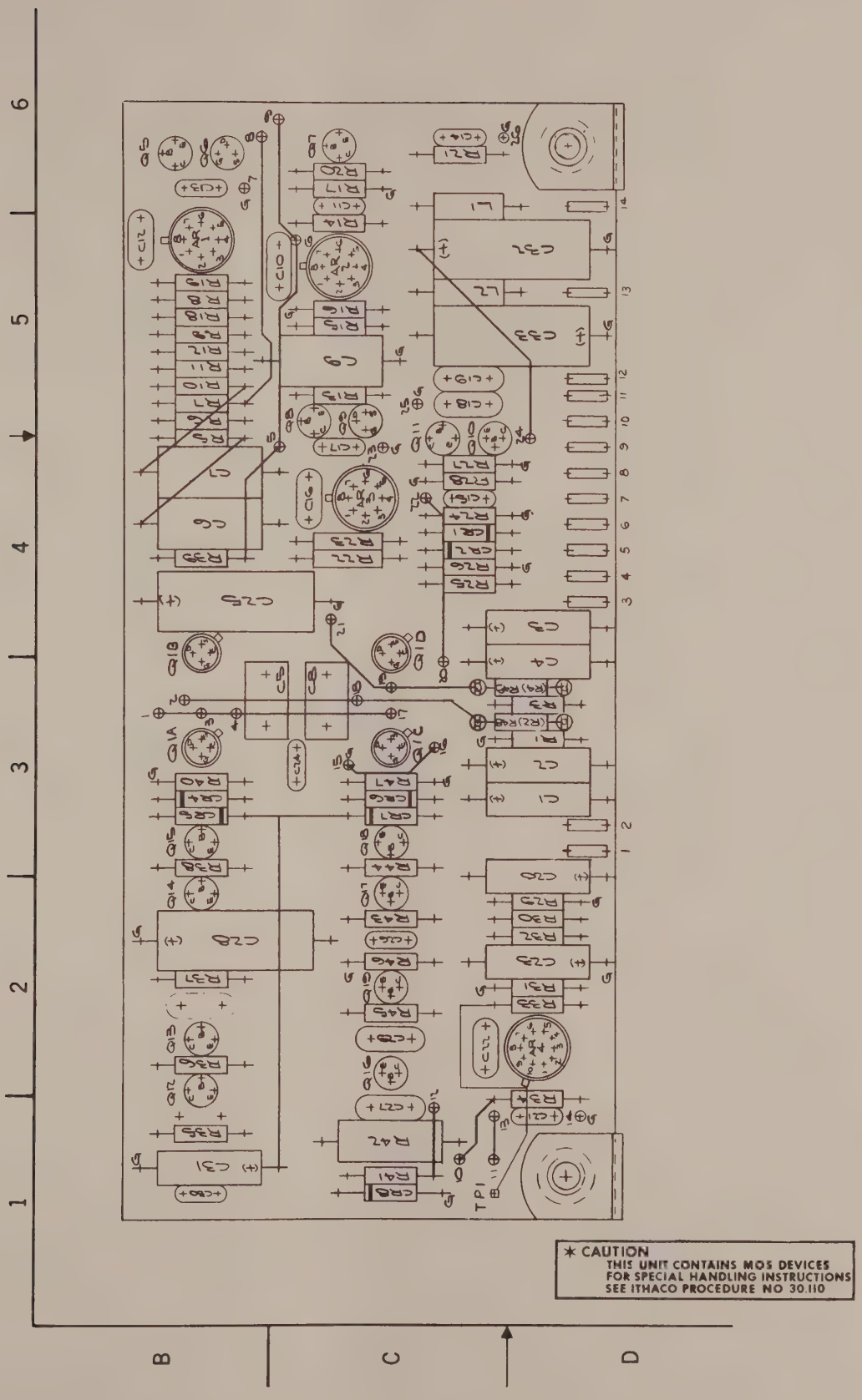
C102
C103
C104
C105
C106
C107



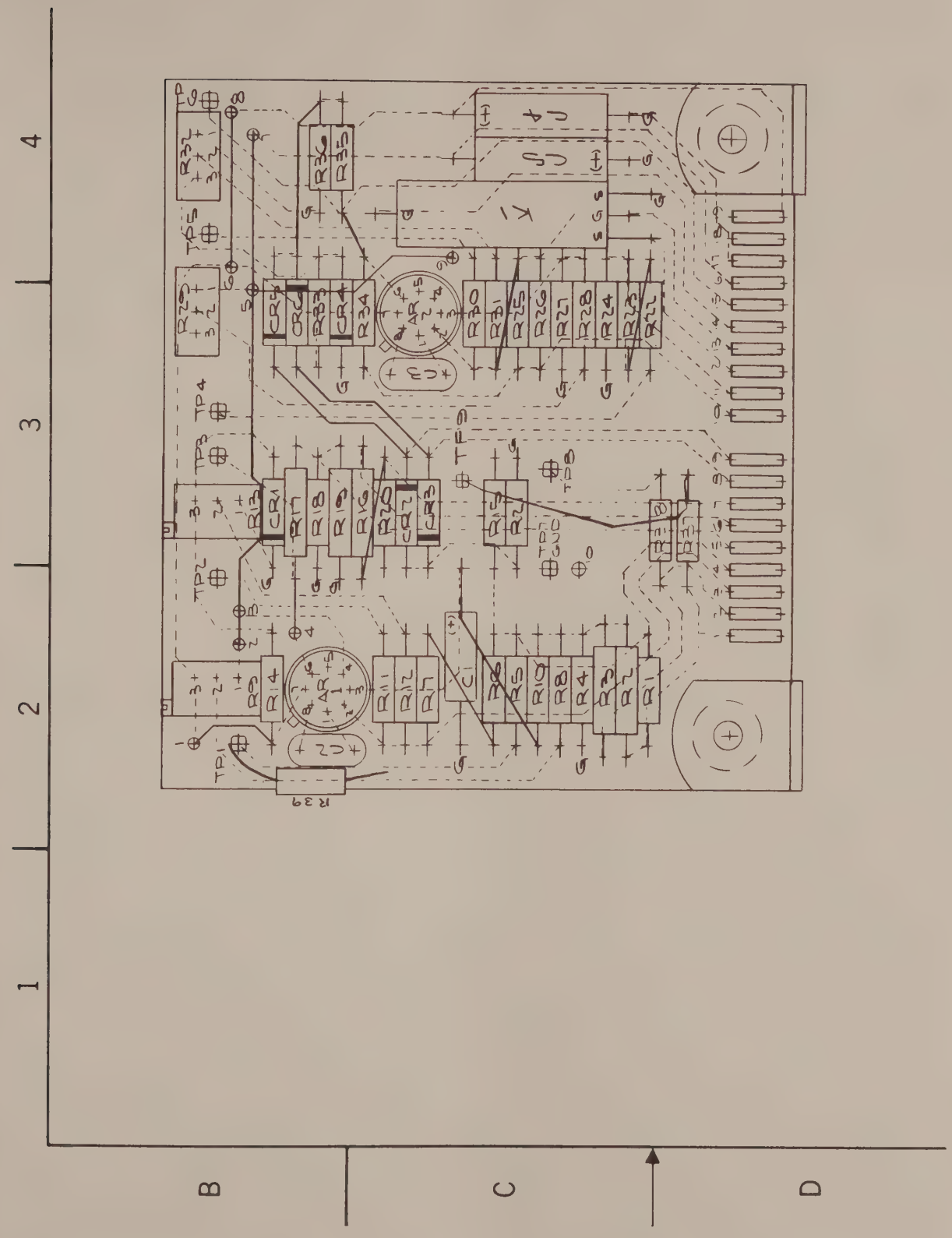
ITHACO DWG C31912, SH 1, REV M, 9/83

FIGURE 7.19 ASSEMBLY – A3 VECTOR SUMMER



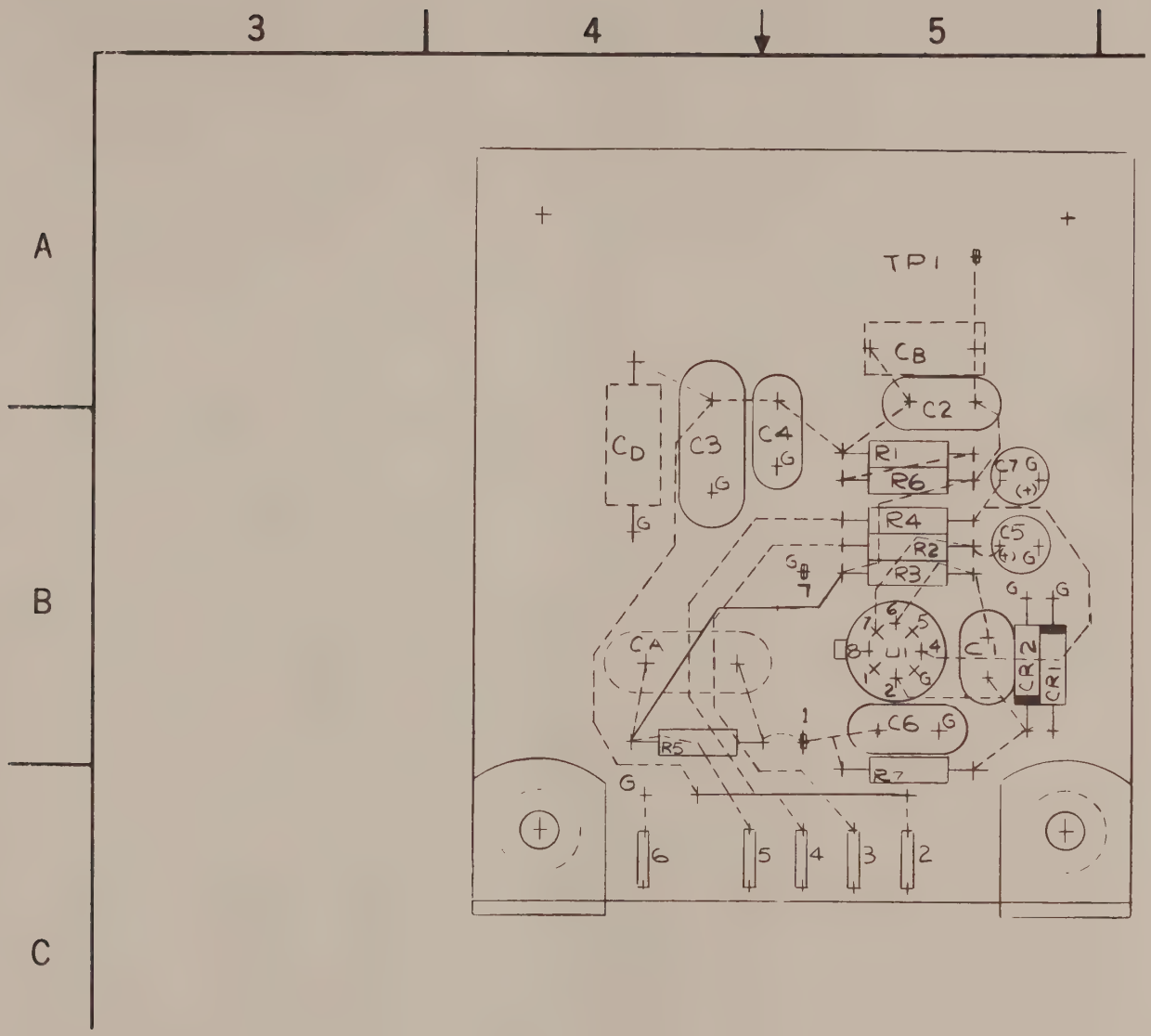
ITHACO DWG C31903, SH 1, REV H, 2/80

FIGURE 7.20 ASSEMBLY – A4 AND A5 PHASE SENSITIVE DETECTOR



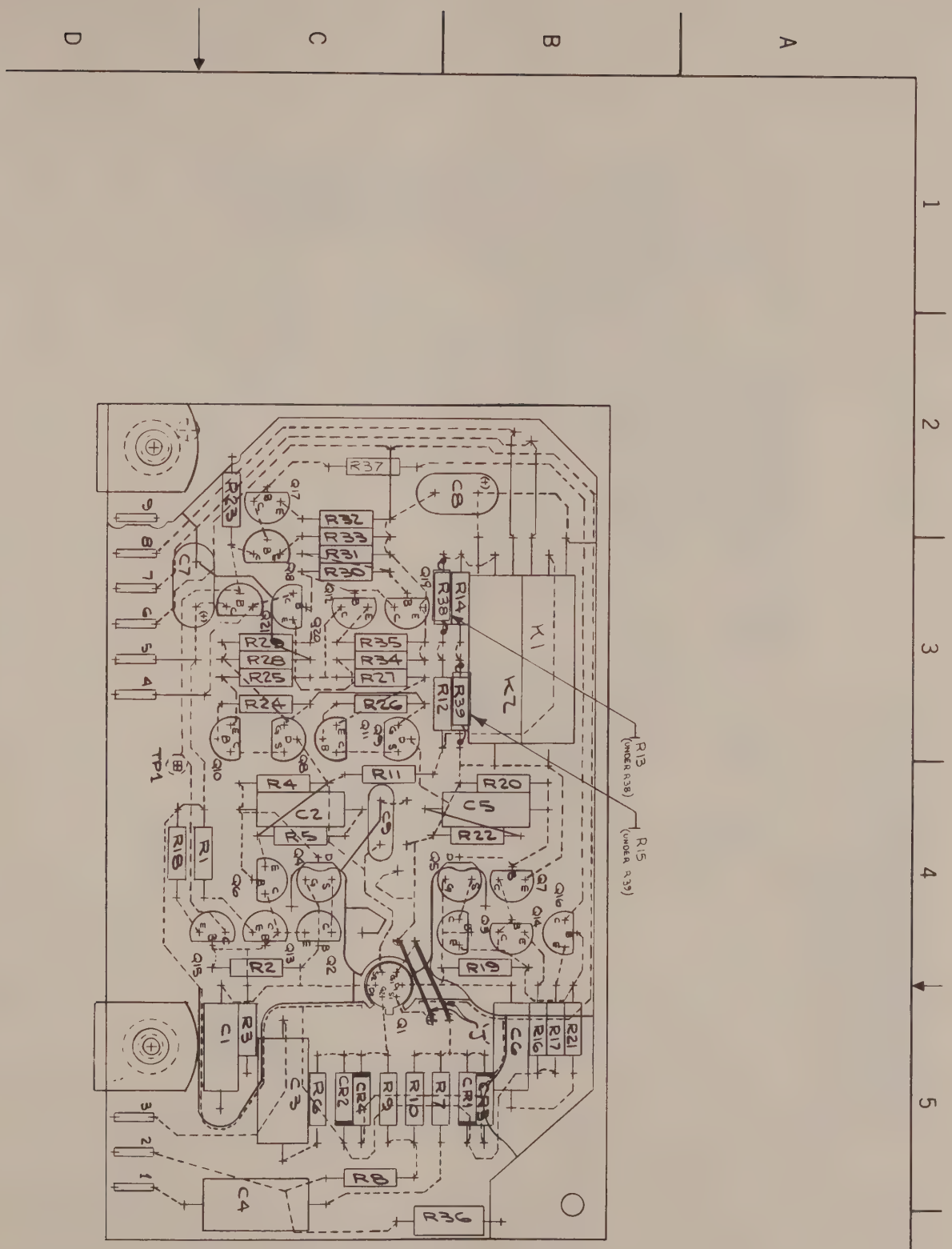
ITHACO DWG C31904, SH 1, REV G, 6/84

FIGURE 7.21 ASSEMBLY – A6 AND A7 LOW PASS AMPLIFIER



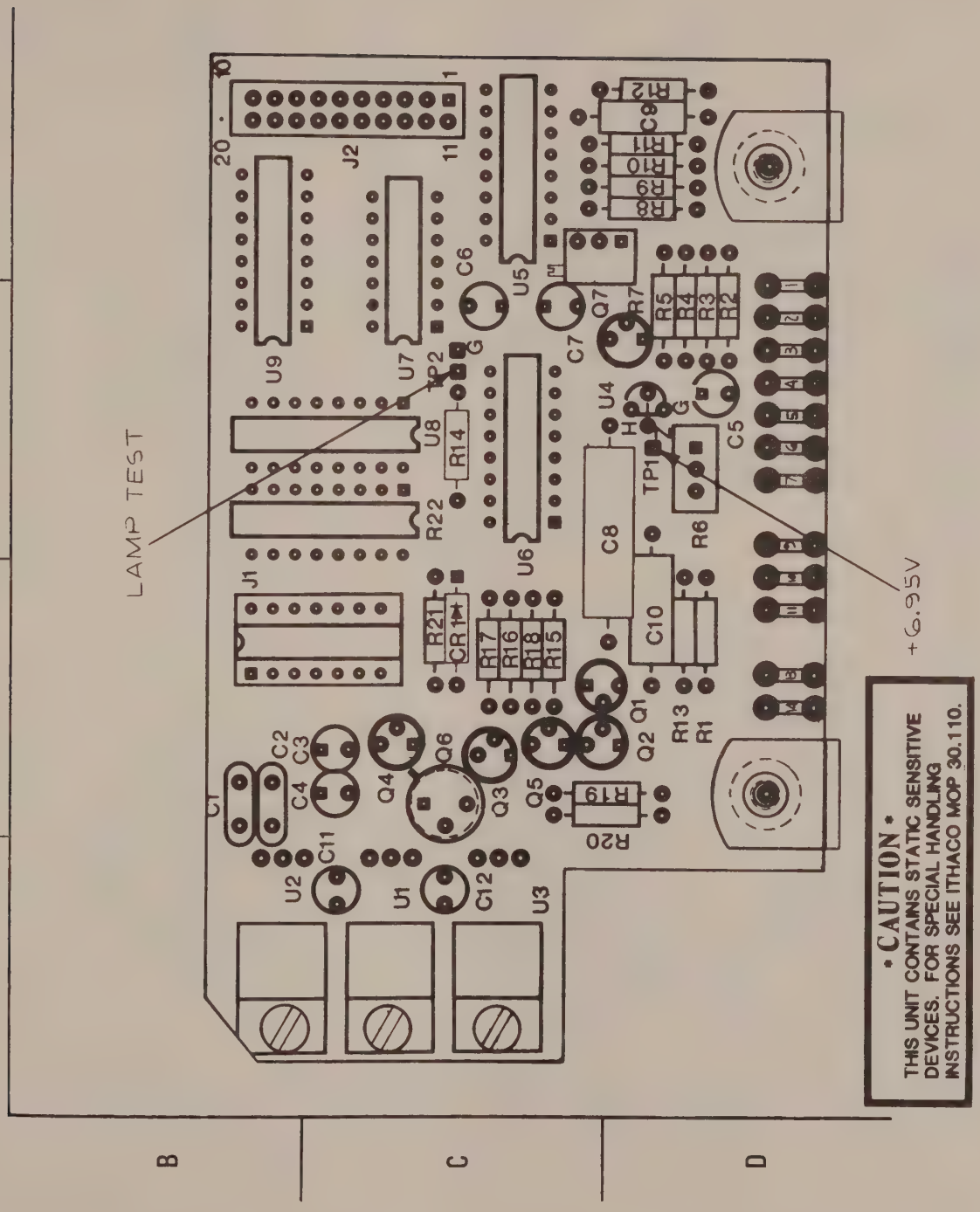
ITHACO DWG C32266, SH 1, REV B, 10/78

FIGURE 7.22 ASSEMBLY – A8 CURRENT PREAMP



ITHACO DWG C32247, SH 1, REV B 10/79

FIGURE 7.23 ASSEMBLY – A9 VOLTAGE PREAMP



ITHACO DWG C32851, SH 1, REV B, 9/84

FIGURE 7.24 ASSEMBLY – A10 DVM CARD

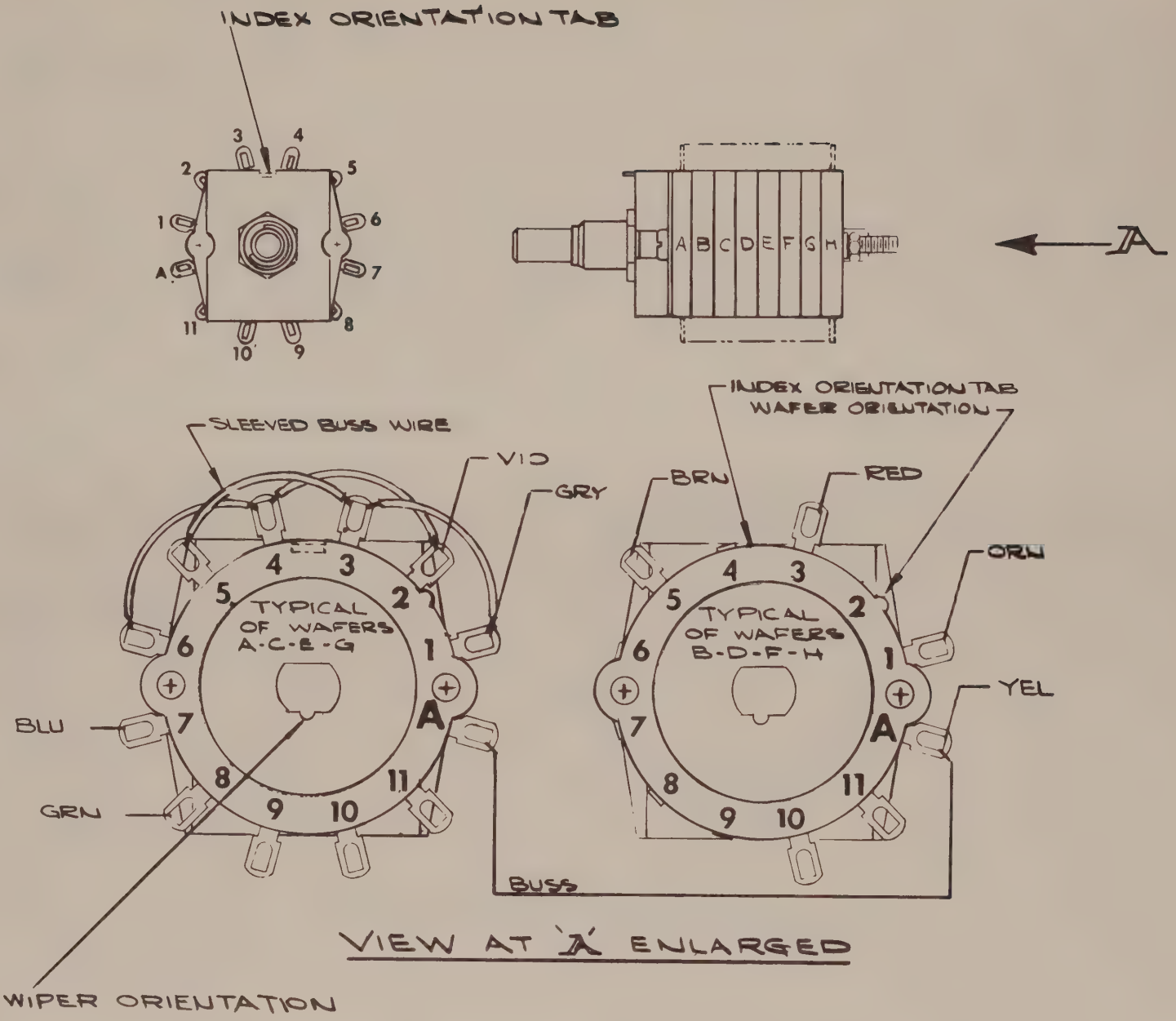


FIGURE 7.25 ASSEMBLY – TIME CONSTANT SWITCH

ITHACO DWG B22645, REV A, 4/78

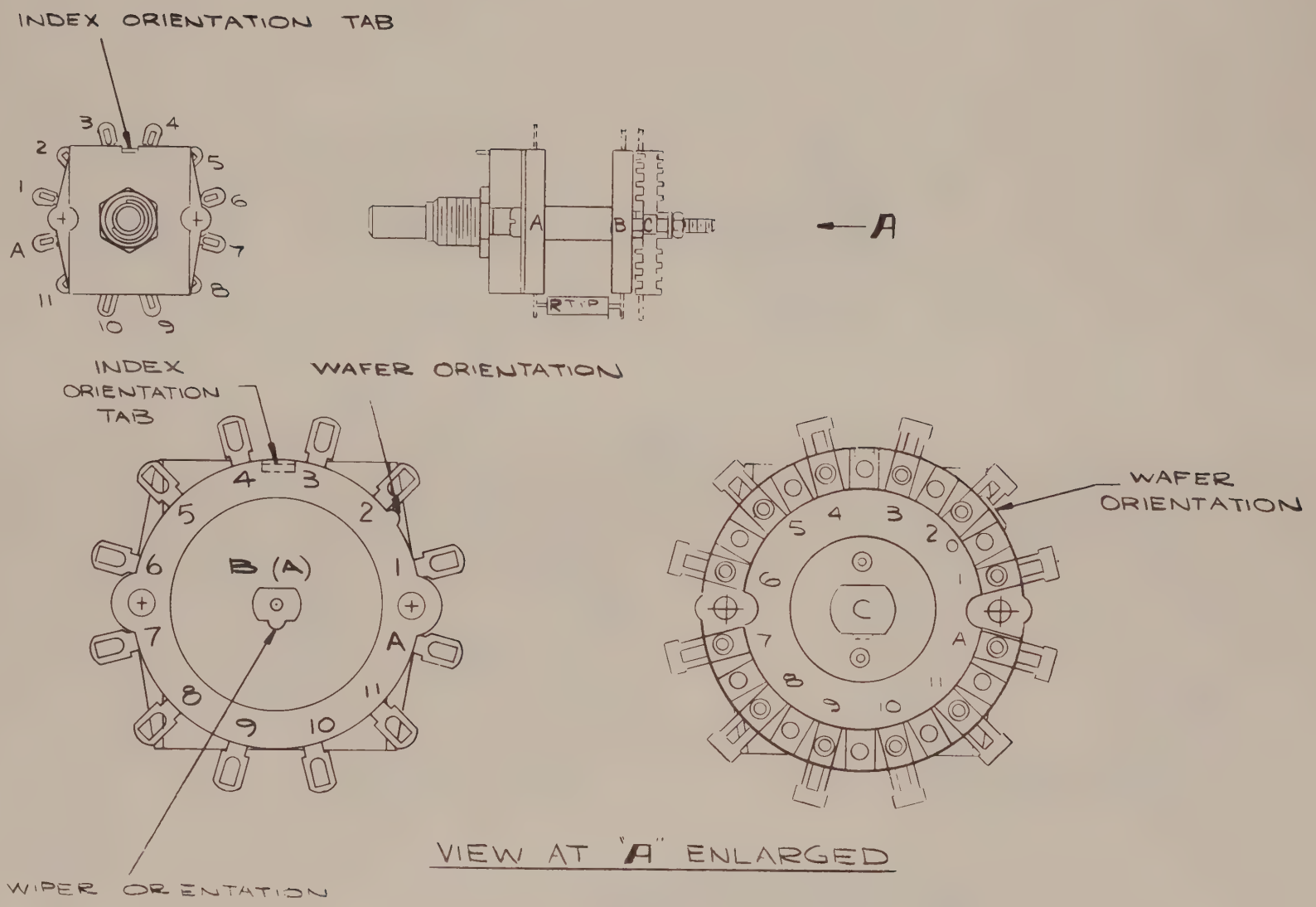
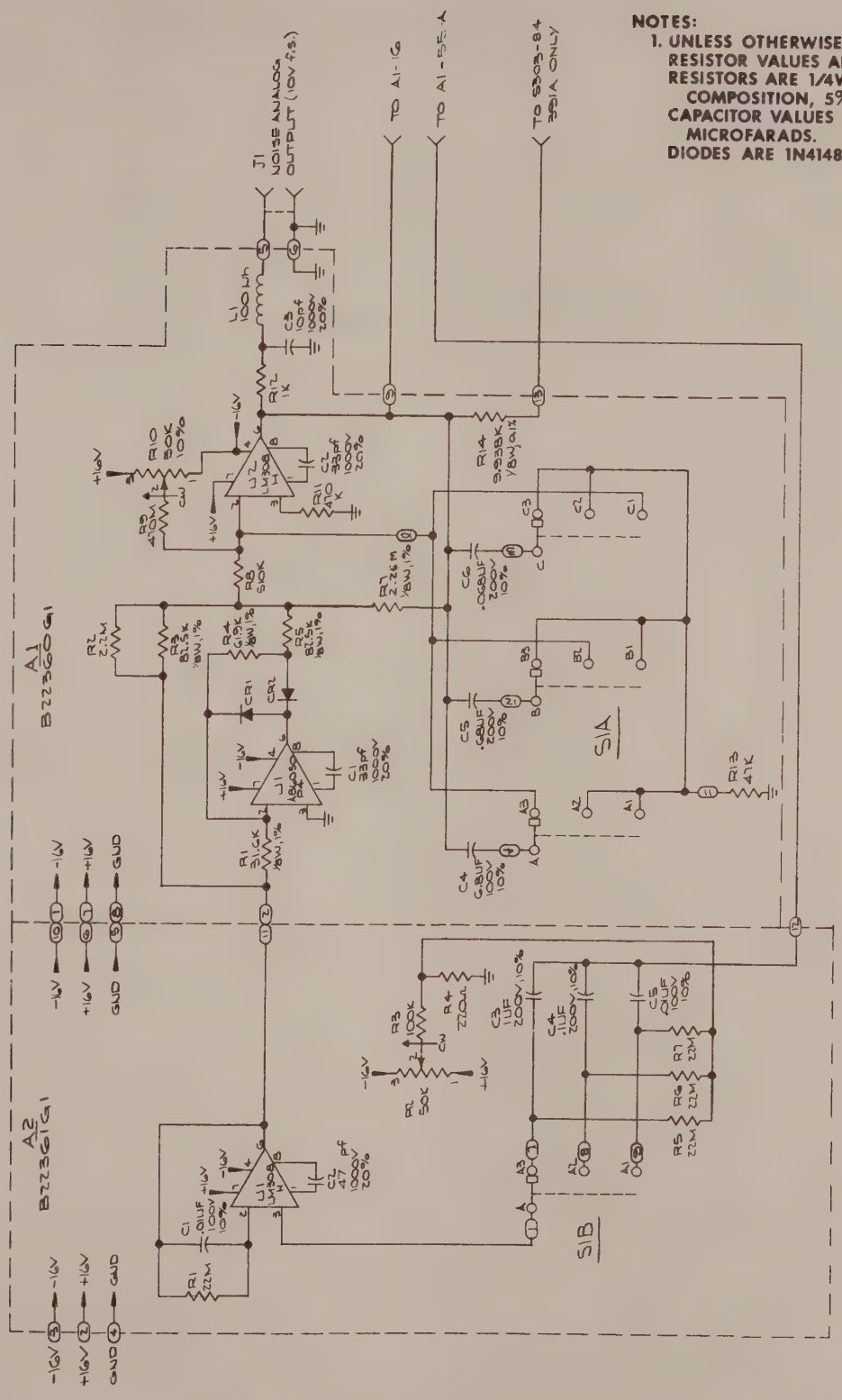
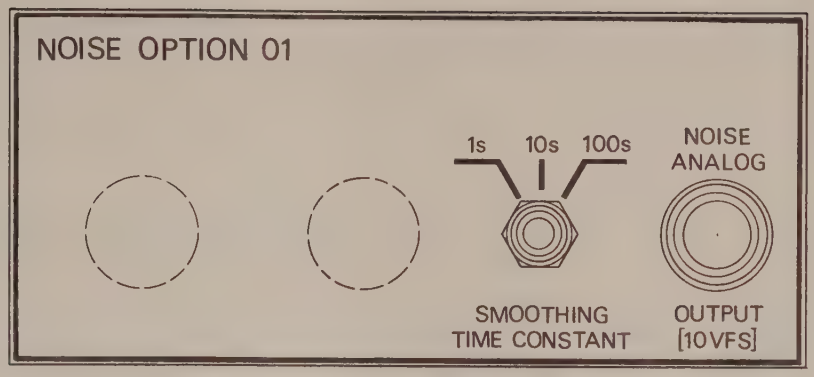


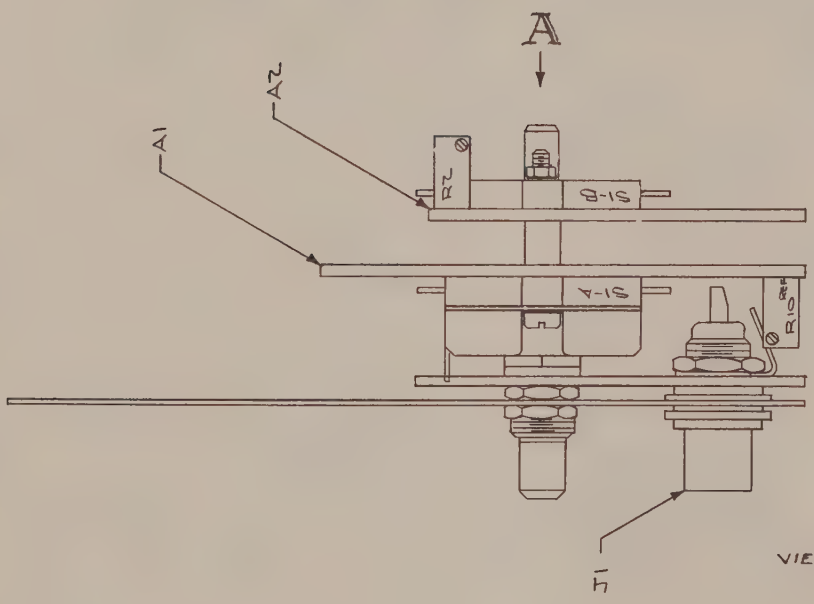
FIGURE 7.26 ASSEMBLY – ZERO SUPPRESS SWITCH

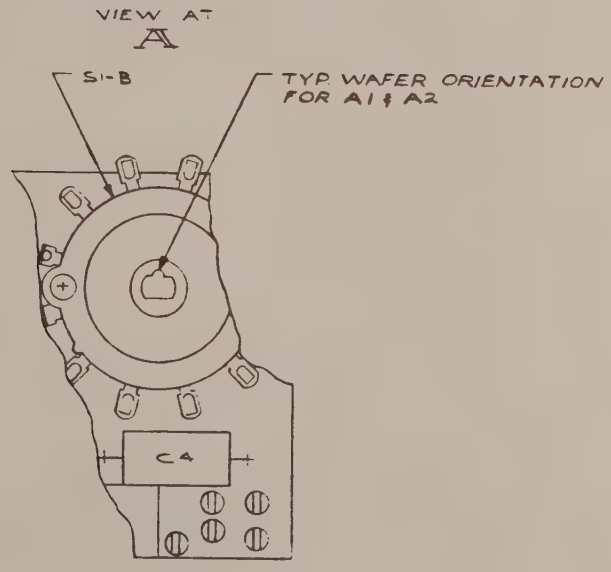
ITHACO DWG B22649, REV A, 7/78



ITHACO DWG C31948, SH 1, REV C, 9/75 FIGURE 7.28 SCHEMATIC – OPTION 01 – OUTPUT NOISE DETECTOR







ITHACO DWG C31947, SH 1, REV B, 4/80 FIGURE 7.29 ASSEMBLY – OPTION 01 – OUTPUT NOISE DETECTOR

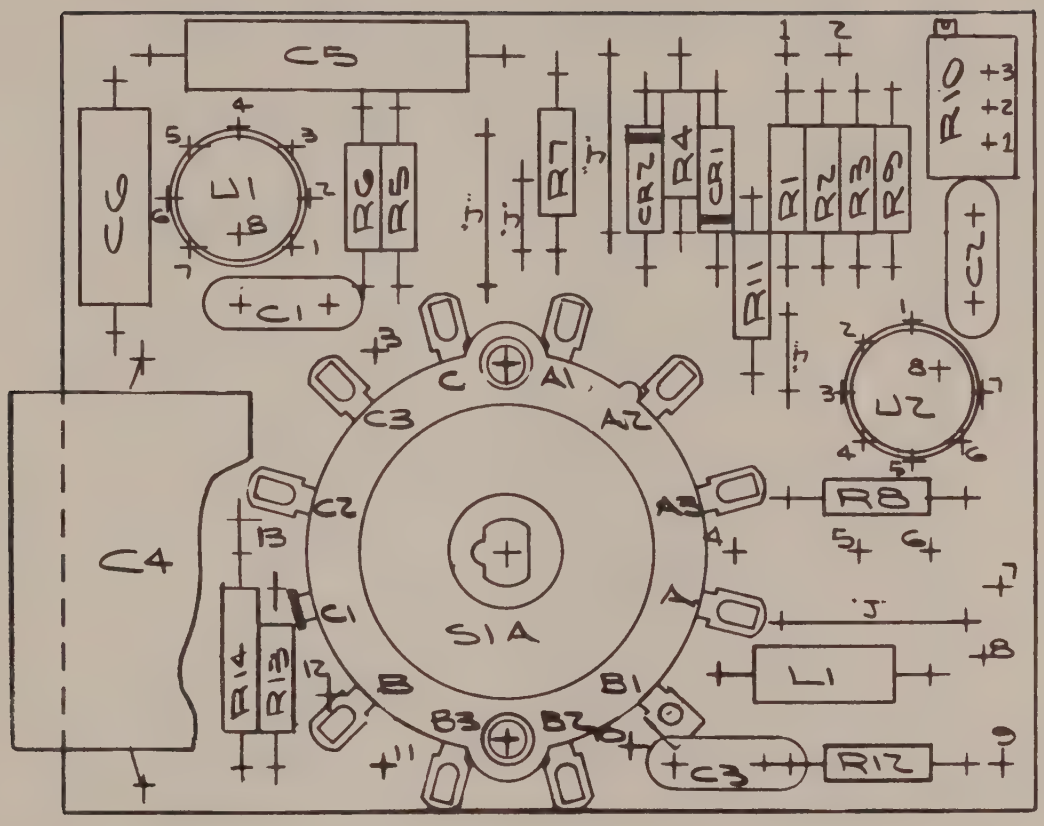


FIGURE 7.30 ASSEMBLY – OPTION 01
OUTPUT NOISE DETECTOR – A1 CARD

ITHACO DWG B22360, SH 1, REV D, 7/79

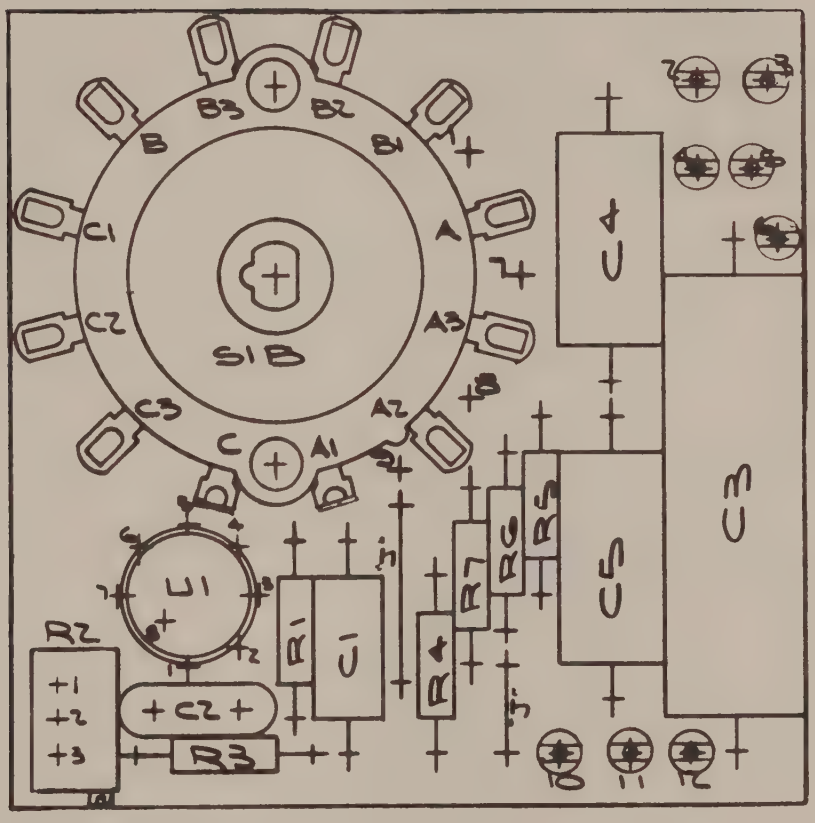
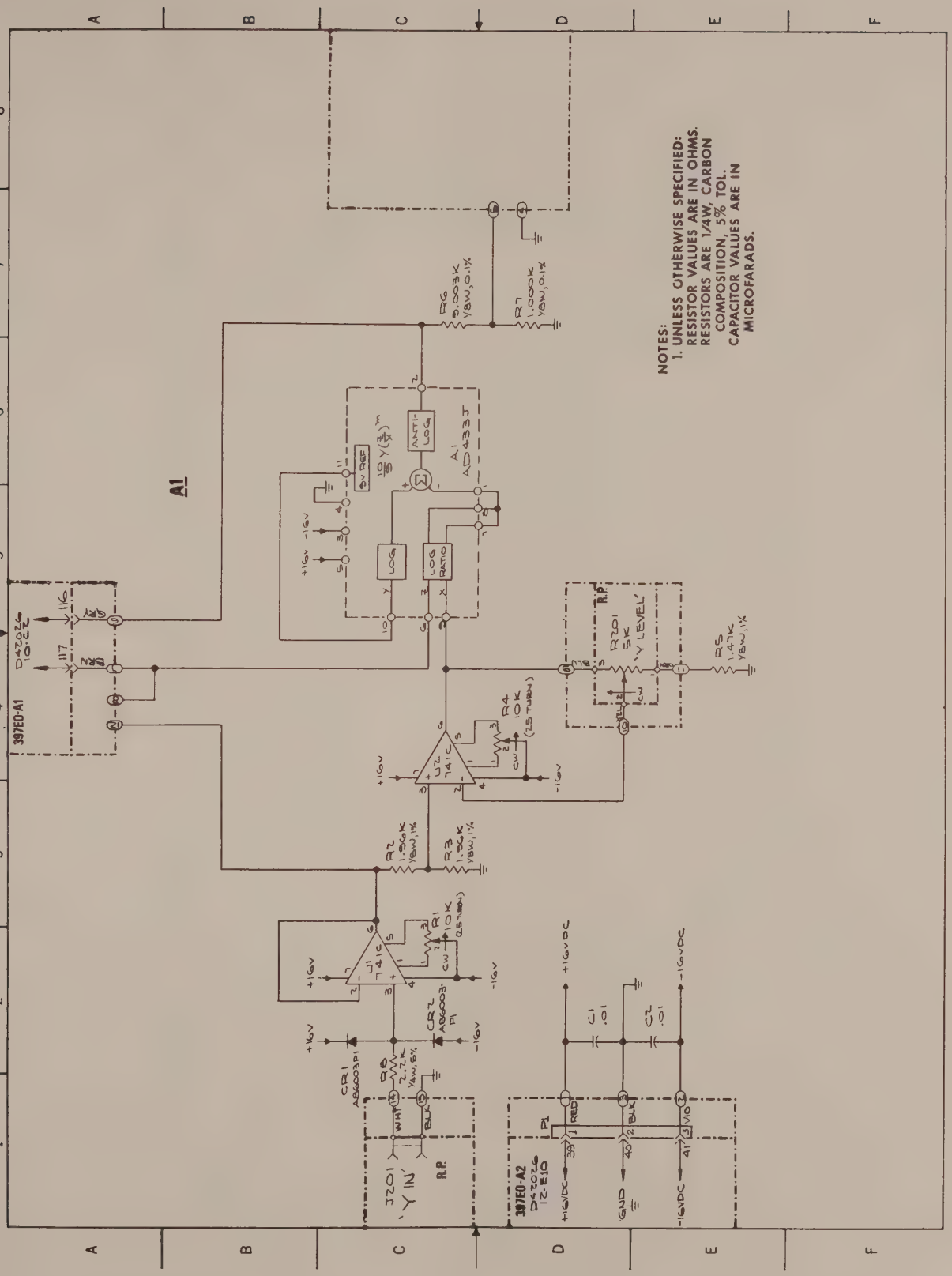


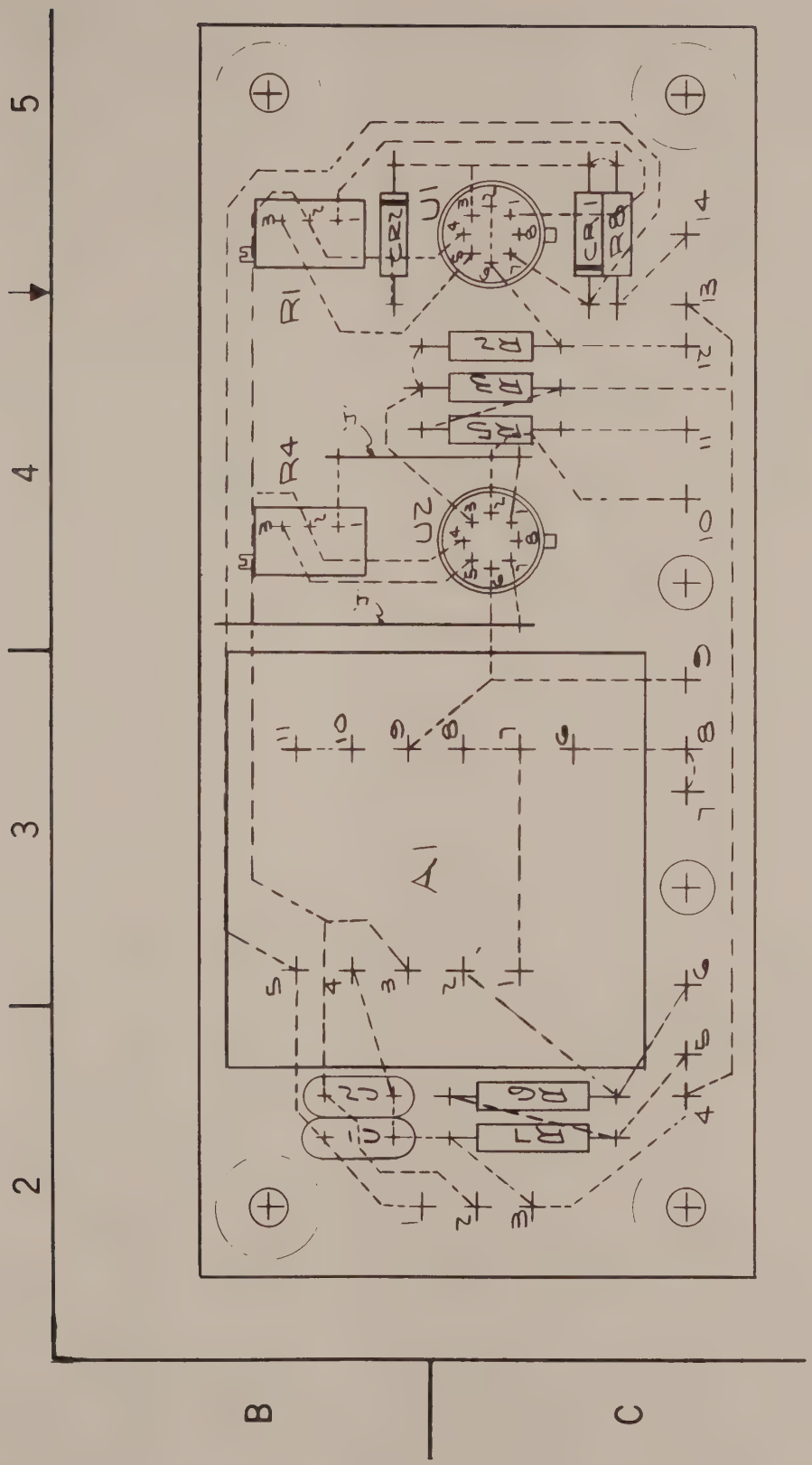
FIGURE 7.31 ASSEMBLY – OPTION 01
OUTPUT NOISE DETECTOR – A2 CARD

ITHACO DWG B22361, SH 1, REV B, 11/78



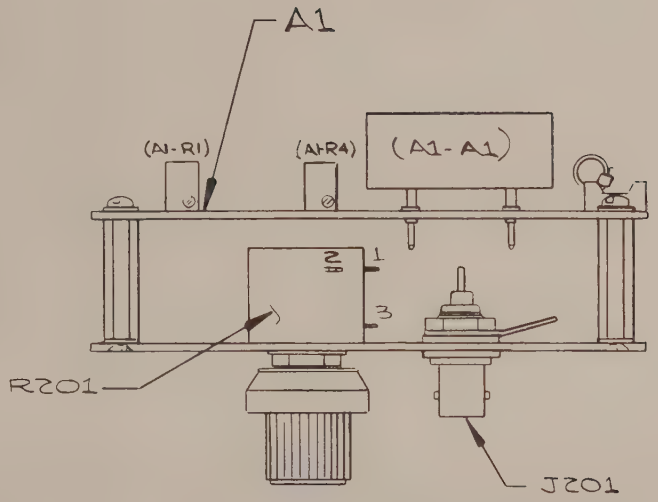
ITHACO DWG C32279, 6/78

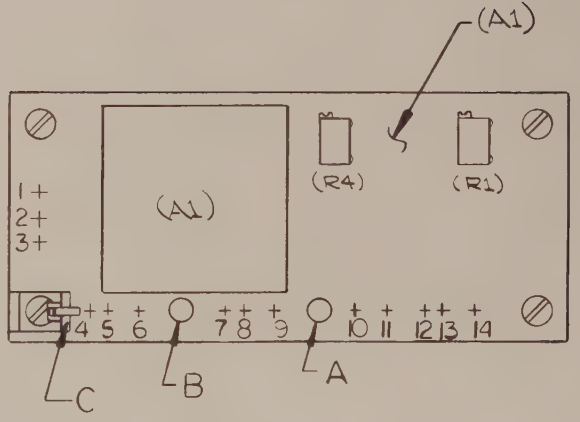
FIGURE 7.32 SCHEMATIC – RATIO OPTION 02E0

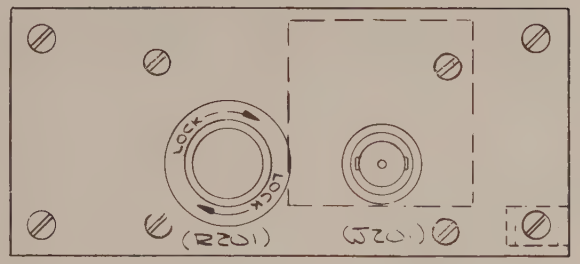


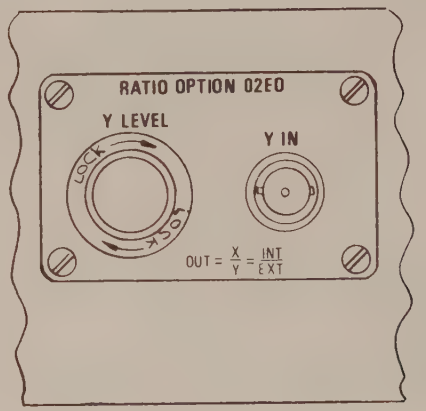
ITHACO DWG C32129, 10/76

FIGURE 7.33 ASSEMBLY – RATIO OPTION 02EO



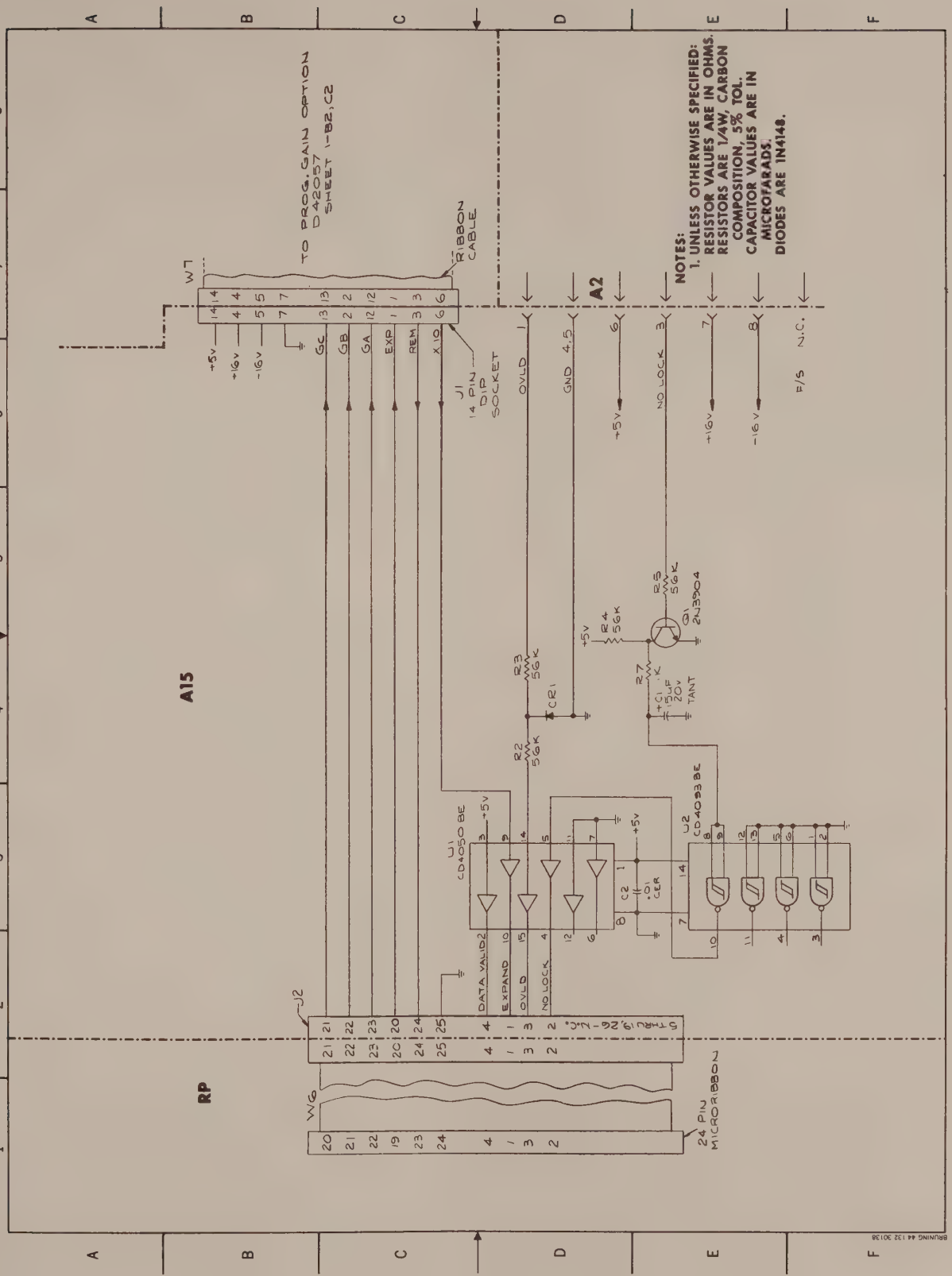






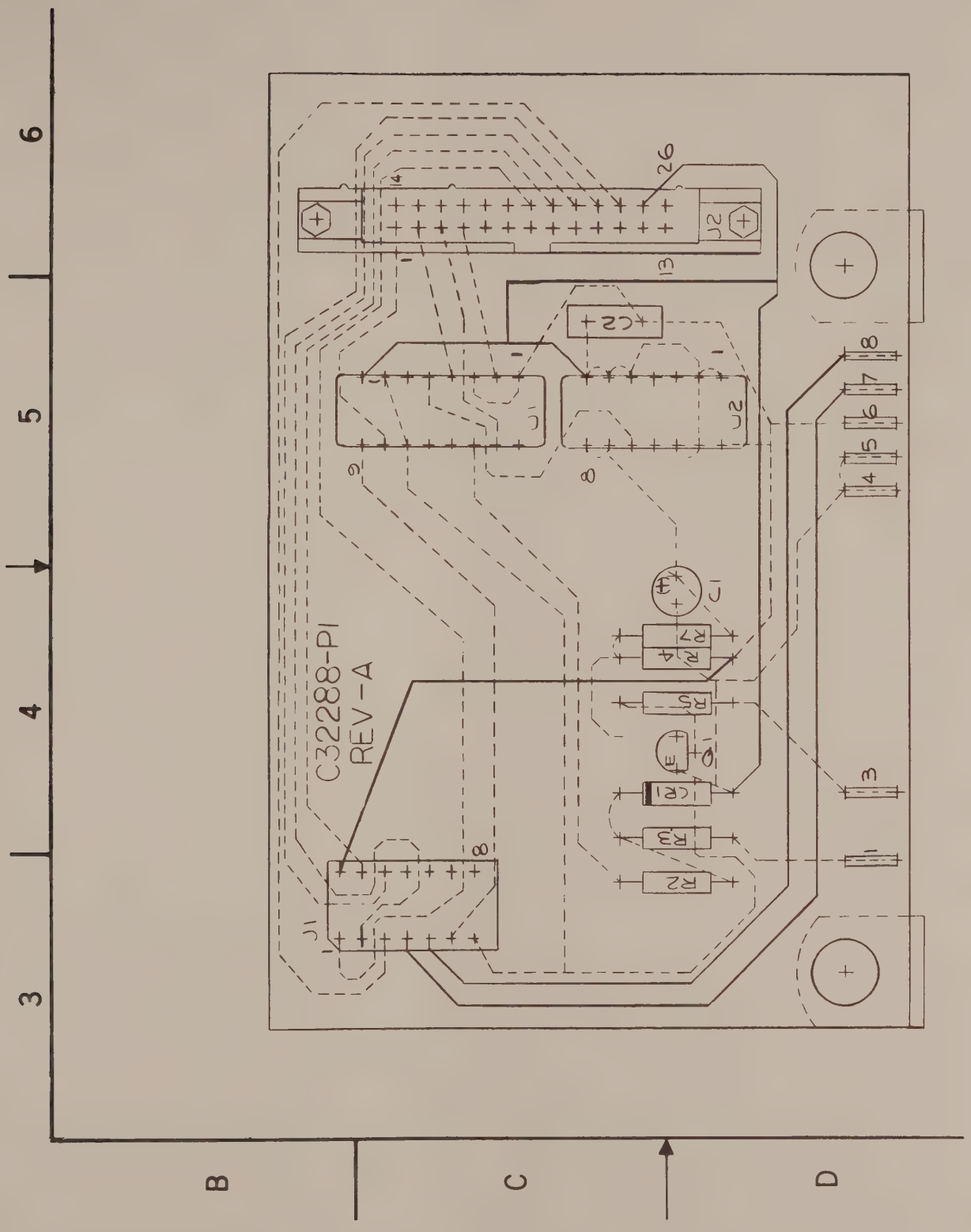
ITHACO DWG C32278, REV B, 4/80

FIGURE 7.34 ASSEMBLY – RATIO OPTION 02E0 CARD



ITHACO DWG C32282, REV A, 6/78

FIGURE 7.35 SCHEMATIC – PROGRAMMABLE GAIN OPTION 06



ITHACO DWG C32288, REV A, 6/78

FIGURE 7.36 ASSEMBLY – PROGRAMMABLE GAIN OPTION 06

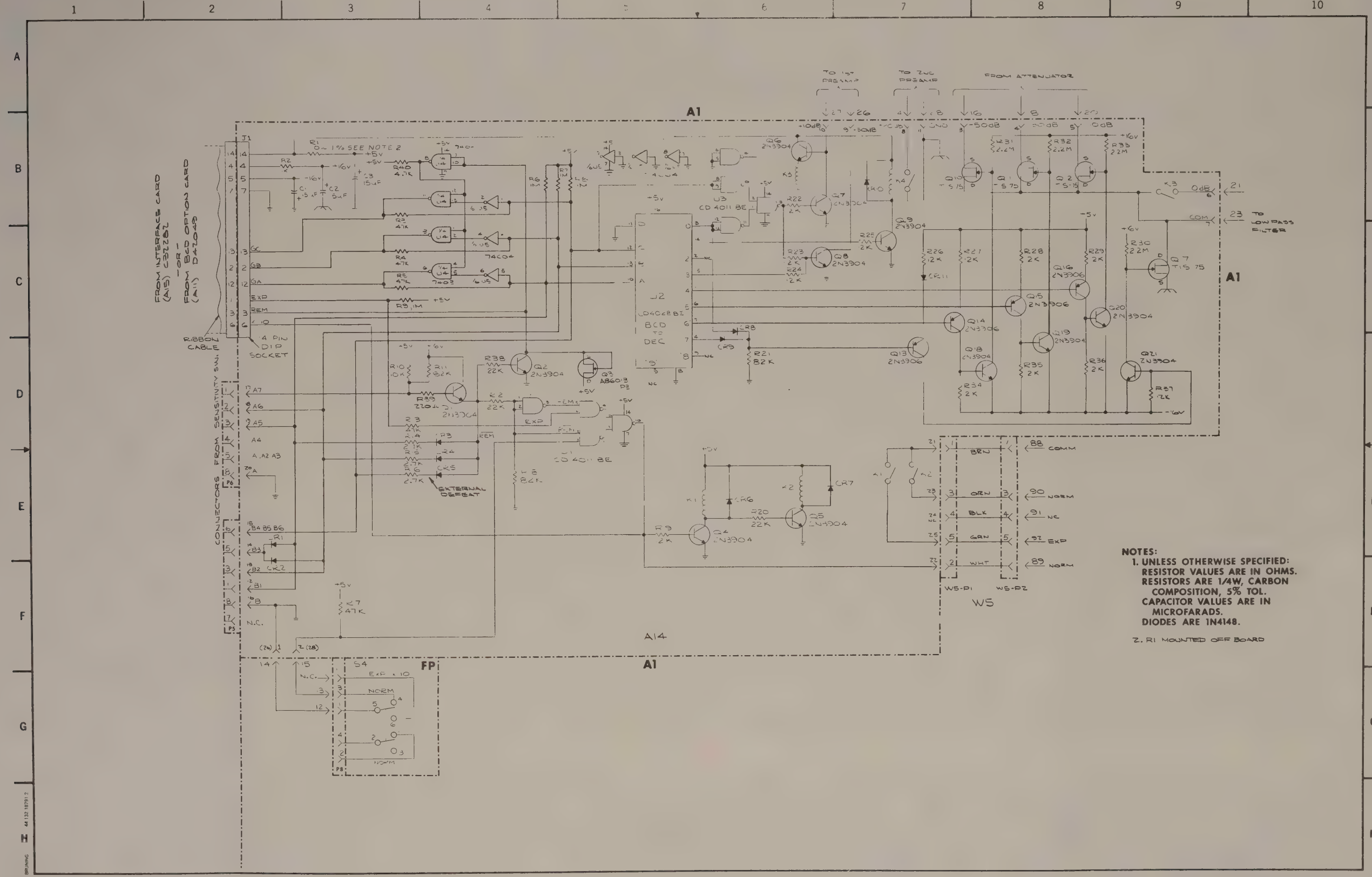
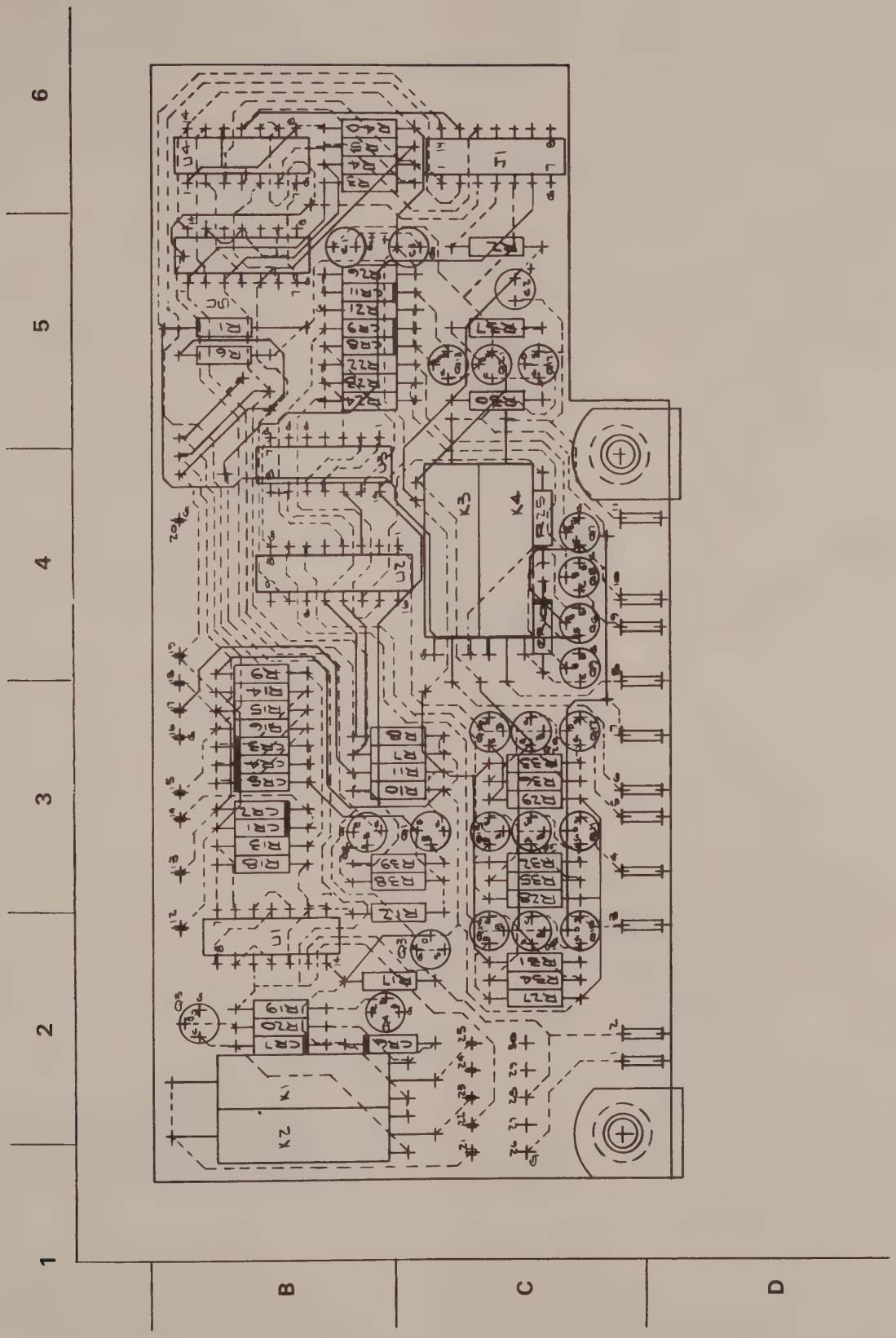
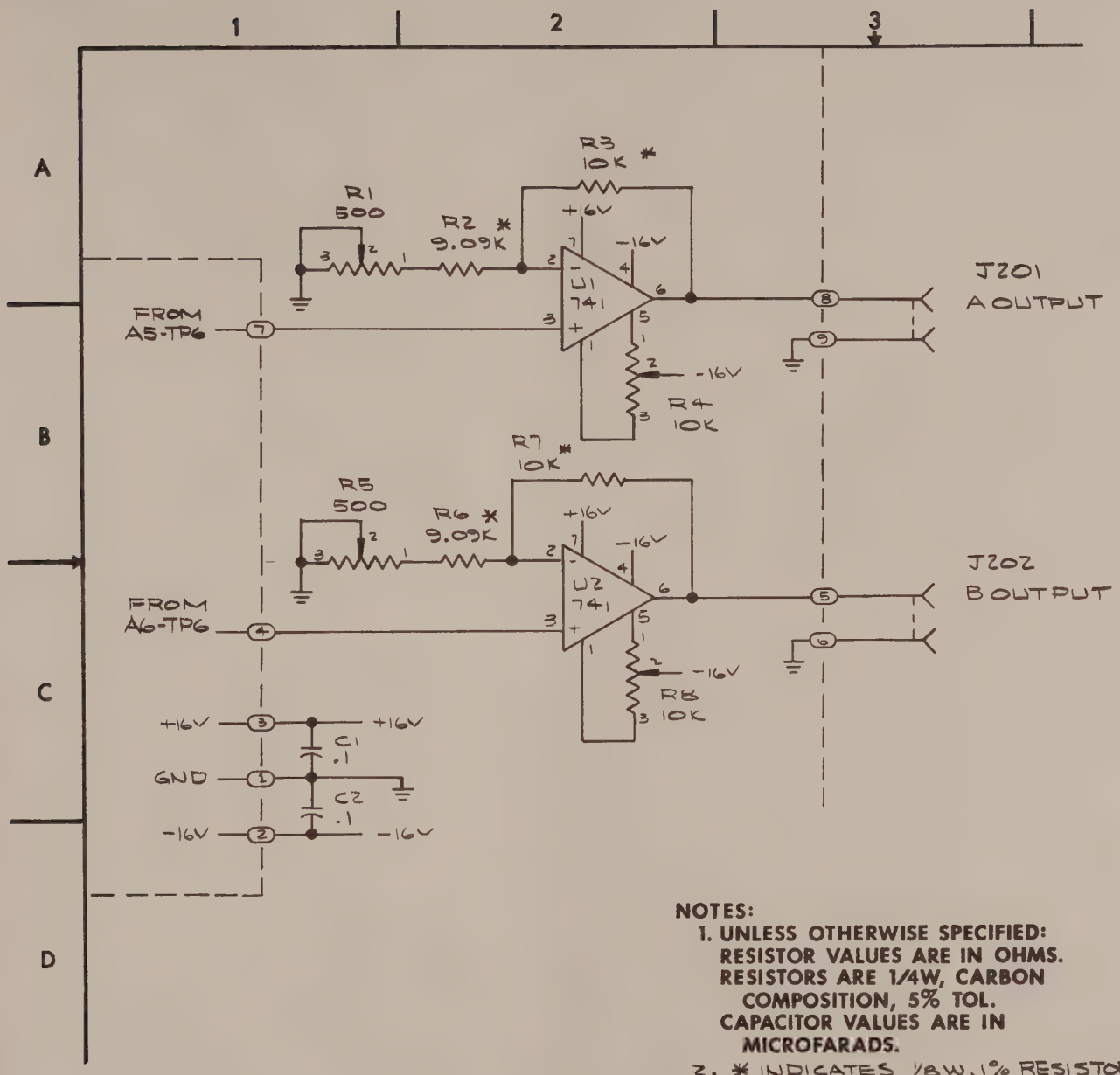


FIGURE 7.37
SCHEMATIC
OPTION 06 SWITCHING CARD



ITHACO DWG C32287, REV F, 1/83

FIGURE 7.38 ASSEMBLY – OPTION 06 SWITCHING CARD



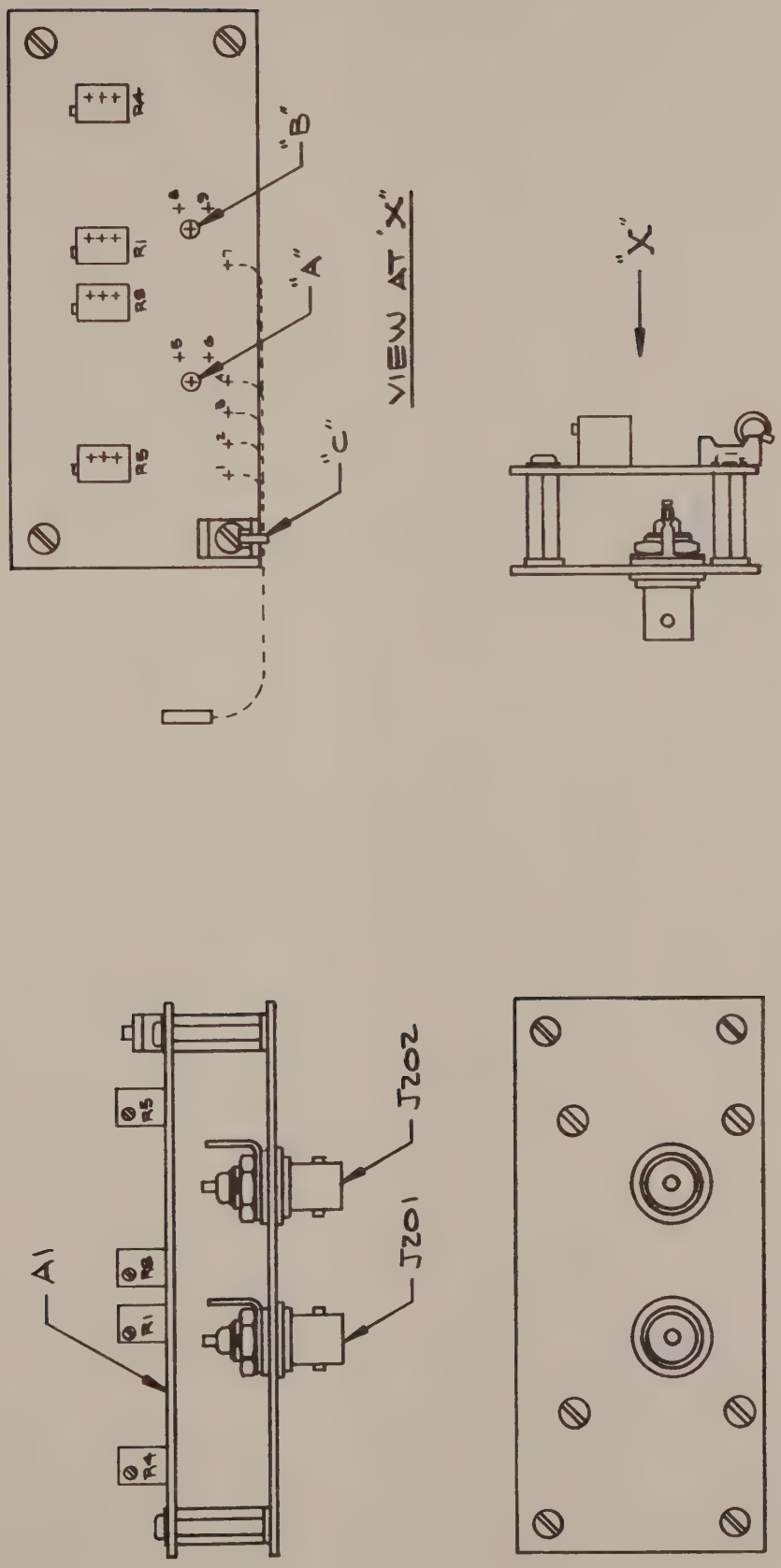
NOTES:

1. **UNLESS OTHERWISE SPECIFIED:**
   RESISTOR VALUES ARE IN OHMS.
   RESISTORS ARE 1/4W, CARBON COMPOSITION, 5% TOL.
   CAPACITOR VALUES ARE IN MICROFARADS.
2. * INDICATES 1/8W, 1% RESISTOR

*** CAUTION ***
THIS UNIT CONTAINS STATIC SENSITIVE DEVICES. FOR SPECIAL HANDLING INSTRUCTIONS SEE ITHACO MOP 30.110.

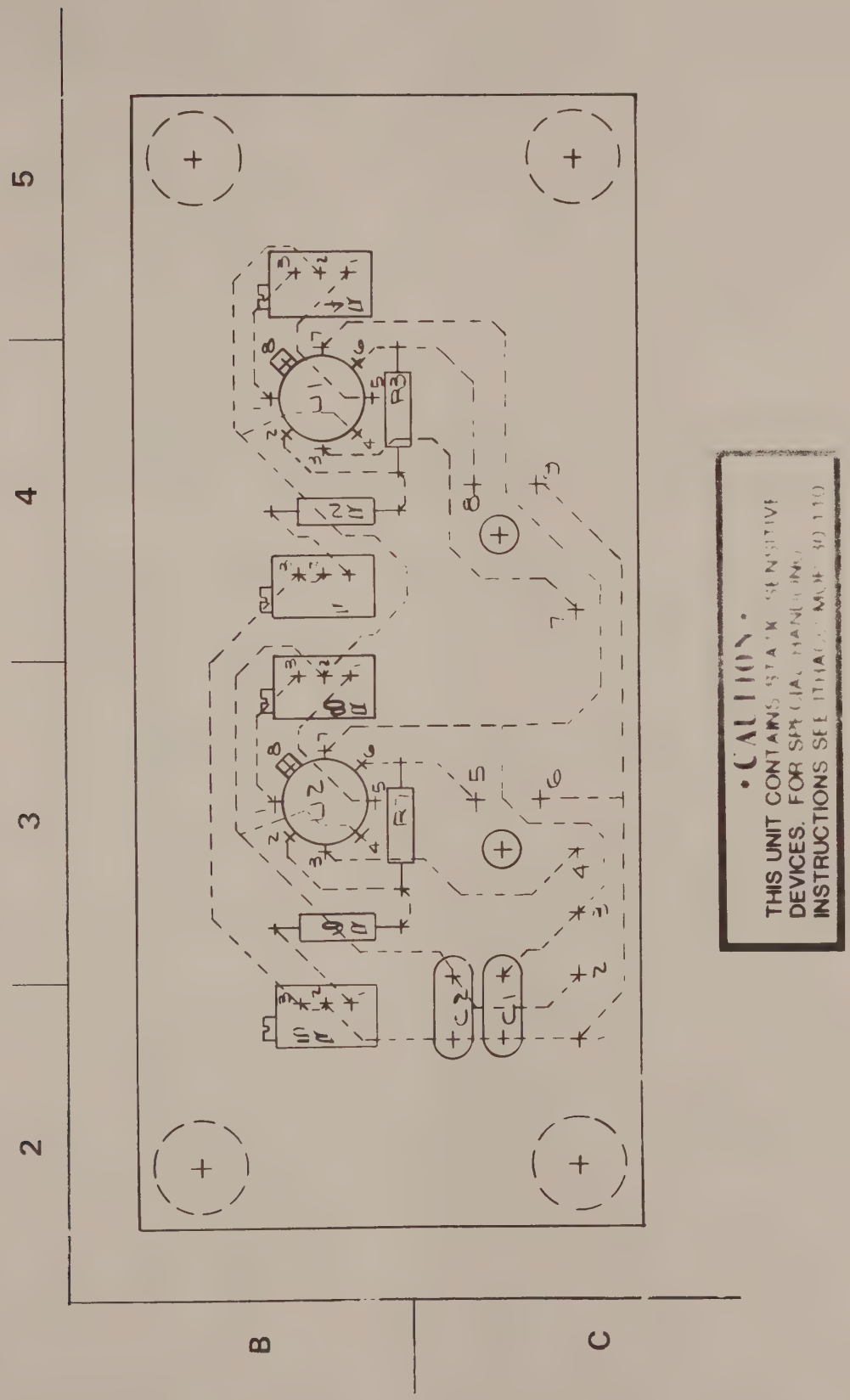
ITHACO DWG B22992, SH 1, REV A, 2/84

FIGURE 7.39 SCHEMATIC – OPTION 10 A–B OUTPUTS



ITHACO DWG C32771, SH 1, REV B, 2/84

FIGURE 7.40 ASSEMBLY – OPTION 10 A–B OUTPUTS



ITHACO DWG C32768, SH 1, REV A, 2/84

FIGURE 7.41 CARD ASSEMBLY – OPTION 10 A–B OUTPUTS

APPENDIX A

The information in this appendix is only relevent to Serial Numbers 65974 and below.

A3 OPERATING INSTRUCTIONS

OPTION 05 BCD OUTPUT

A3.1 DESCRIPTION

The BCD Output Option provides a digital output of the 397EO Digital Voltmeter reading and several status bits indicating the general status of the lock-in. This allows the user to attach the lock-in to a printer or a digital data acquisition system.

All outputs produce a standard 0 to 5 volt swing with +5 volts being the true state. These outputs will drive up to 2 standard TTL loads, and are protected against short circuits to either +5 volts or ground. The function of each output is described below. See Table A3.1 for Summary of pin connections.

DVM DATA LINES (pins 6 thru 18 on J15) - The reading on the Digital Voltmeter is represented by 4 groups of BCD (8421) data, each group representing one digit on the DVM. The 3 least significant digits are represented by 4 bits each while the most significant digit is only one bit. These data lines are named so that their name represents their value in percent of full scale. Thus the most significant bit "100" (pin 6) represents 100% F.S. and the least significant bit ".1" (pin 18) represents 0.1% F.S. These values are latched internally, and available continuously.

DATA VALID LINE (J15, pin 4) - The Data Valid signal is made available and is only true when the reading is stable on the DVM DATA LINES. This signal becomes true once after each conversion (whether the data has changed or not) and stays true for approximately 0.1 seconds. A new sample is taken approximately every 0.3 seconds. The DATA VALID signal does not indicate any fault conditions such as DVM overrange.

Figure A3.1 shows the relative timing of the DVM and the DATA VALID signals.

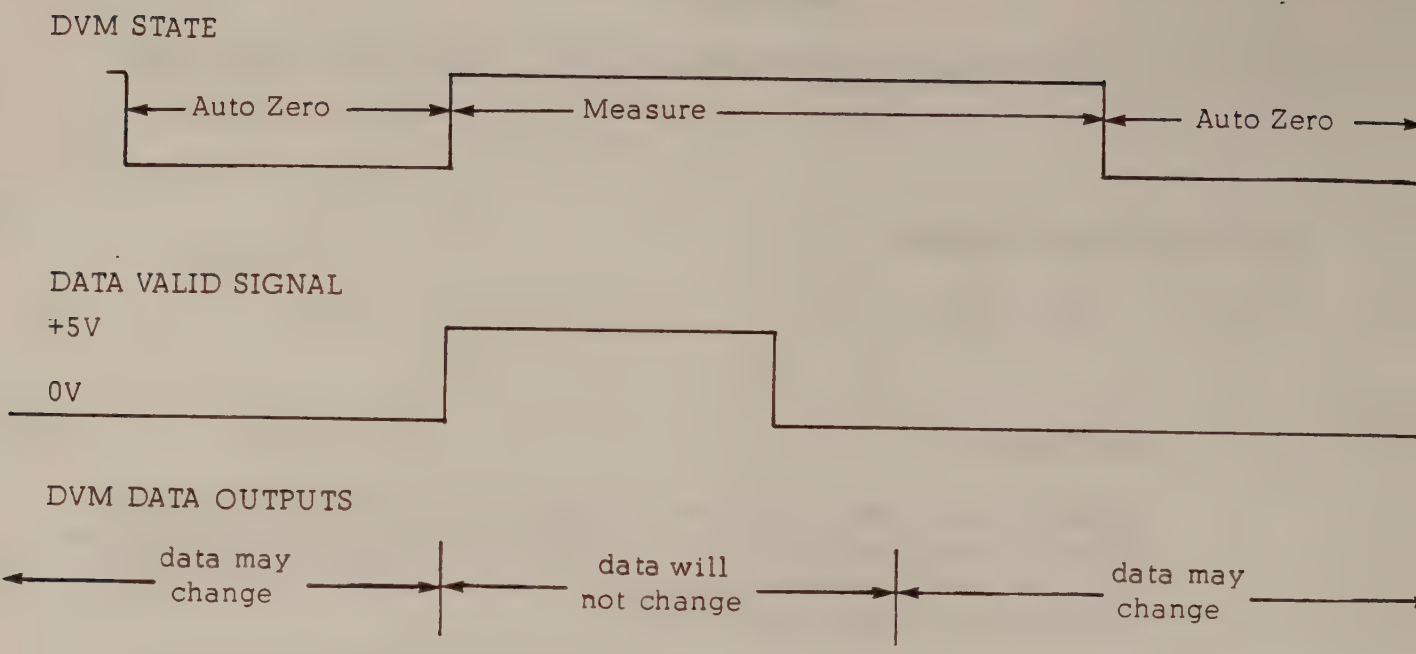


FIGURE A3.1

SIGN (J15, pin 5) - The SIGN signal indicates the sign of the DVM reading. +5V indicates a positive reading, while 0V indicates a negative reading. This signal, like the DVM DATA is always valid when the DATA VALID signal is true.

OVERLOAD SIGNAL (J15, Pin 3) - The OVERLOAD signal (OVLD) indicates the status of the amplifiers in the lock-in. This signal becomes true whenever the OVERLOAD LIGHT is on. All points within the lock-in are checked for overload except the DVM which can be checked by observing its Digital Output value. (Any value exceeding ±125% should be considered to be overloaded.) The only time that the DVM will overload without the OVLD signal going true is when the lock-in output is EXPANDed.

NO LOCK SIGNAL (J15, pin 2) - The NO LOCK signal is used to indicate when the Reference circuits have not acquired lock. This signal will remain true whenever the NO LOCK light is on or blinking. Approximately one half second after the light is extinguished, the NO LOCK signal will become false.

EXPAND SIGNAL (J15, pin 1) - This signal indicates the status of the EXPAND X10 circuit in the lock-in. When the output is expanded, the EXPAND signal will be true (+5VDC).

GROUND (J15, pin 24) - The digital ground which is internally connected to chassis ground, is available at pin 24. This wire should be connected to the digital ground of any equipment and shields of any wires connected to J15.

A3.1.1 SPECIFICATIONS

Output Levels:	V_{OH}	5 VDC nominal
(All Outputs)	V_{OL}	0 VDC
Output Drive:	I_{OL}	3.2mA min @ V_o = +0.4V
(All Outputs)	I_{OH}	-800μA min @ V_o = +4.5V
Conversion Time:		0.3 sec typical
"DATA VALID" Signal:		Duty Cycle -33%
All Signals:		positive - true logic
Output Connector:		24 pin Micro Ribbon* (same as IEEE 488 connector)
Output Format:		Signed BCD; 3 1/2 digit

* Trademark of Amphenol

A3.2 PROGRAMMABLE GAIN AND BCD OPTION COMBINED

The 397EO can be equipped with either Option 05 or 06, or both. When both are supplied, they share the rear panel connector J15. The only conflict which arises is the DATA VALID signal. When both options are supplied, this functions as described in Section A3.1 for the BCD Option.

ITHACO 397EO LOCK-IN AMPLIFIER

AUXILIARY CONNECTOR J15

Pin No.	BCD Opt 05	PROG Opt 06	05 & 06	397EO
1	EXPAND STATUS	EXPAND STATUS	EXPAND STATUS	+5 = EXPANDED
2	NO LOCK	NO LOCK	NO LOCK	+5 = NO LOCK
3	OVLD	OVLD	OVLD	+5 = OVLD
4	DATA VALID I	DATA VALID II	DATA VALID I	
5	SIGN	--	SIGN	+5 = POSITIVE
6	MSB (100)	--	MSB (100)	
7	↑	--	↑	
8	|	--	|	
9	|	--	|	
10	|	--	|	
11	|	--	|	
12	BCD	--	BCD	
13	DATA	--	DATA	
14	|	--	|	
15	|	--	|	
16	|	--	|	
17	|	--	|	
18	LSB (.1)	--	LSB (.1)	
19		EXPAND CONTROL	EXPAND CONTROL	+5 = EXPAND
20		GAIN IN: G_C	GAIN IN: G_C	
21		G_B	G_B	
22		G_A	G_A	
23		REMOTE STATUS	REMOTE STATUS	+5 = REMOTE
24	DIGITAL GROUND	DIGITAL GROUND	DIGITAL GROUND	

"1" = 5V
"0" = 0V

DATA VALID I Relates to DATA
DATA VALID II Relates to POWER ON/OFF

TABLE A3.1

A4 TROUBLESHOOTING THE 397EO

A4.1 BCD OUTPUT - OPTION 05

A4.1.1 DESCRIPTION OF OPERATION

Refer to Simplified Schematic Figure A4.1 and Timing Diagrams Figures A4.2 and A4.3.

A4.1.2 DIGITAL VOLTMETER

The Digital Voltmeter converts the lock-in output to a digital number, and displays this information on the LED's. The information for the three least significant digits is output from the DVM chip (U1) as a series of BCD coded digits. The information is then sorted out at the readouts by the digit strobes D1, D2 and D3 and the BCD to 7 segment converter (U4). During the period when D1 is high, the BCD output contains the proper information for the least significant digit of the readout. This is decoded and displayed on the appropriate LED. During the periods when D2 and D3 are true, the appropriate data is sent to the correct LED. The digit strobes and the BCD coded DATA cycle continuously between the three digits.

The most significant digit operates in a somewhat different manner. For the negative sign, a fifth data output, the Sign/overflow/underflow line (SIGN/OF), goes positive during the D3 interval to indicate a positive number. This is inverted and sent to the LED where the result is decoded by the D3 signal. Thus the negative sign acts like part of the D3 digit. For the "1" or overflow output, the data is output on the SIGN/OF data line, during the D2 interval, but is not present for each cycle. Rather, it becomes true only once for each conversion done by the DVM. This one pulse is decoded by an AND gate (part of U2) and stored in time constant T1. The result is then fed to the LED.

The oscillator in the DVM chip operates at a high frequency rate, and is divided down in frequency to produce the scan rate for D1, D2, and D3, and is further divided down to produce the conversion rate. A complete conversion takes 6144 cycles of the oscillator; 2048 cycles for auto zero, and 4096 cycles for measuring.

A4.1.3 BCD OPTION OPERATION (Refer to Figures A4.1, A4.2, A4.3)

The BCD Option takes the scanned outputs from the DVM and latches them so that the outputs will appear continuously. The Option also provides a Data Valid signal and several status signals from the lock-in.

The Data from the three least significant digits is latched in a simple manner. The BCD output data appearing on lines A, B, C and D is sent to latches U8, U9 and U10. Whenever strobe D1 is true, U10 latches the data which represents the least significant digit. U8 and U9 perform similarly.

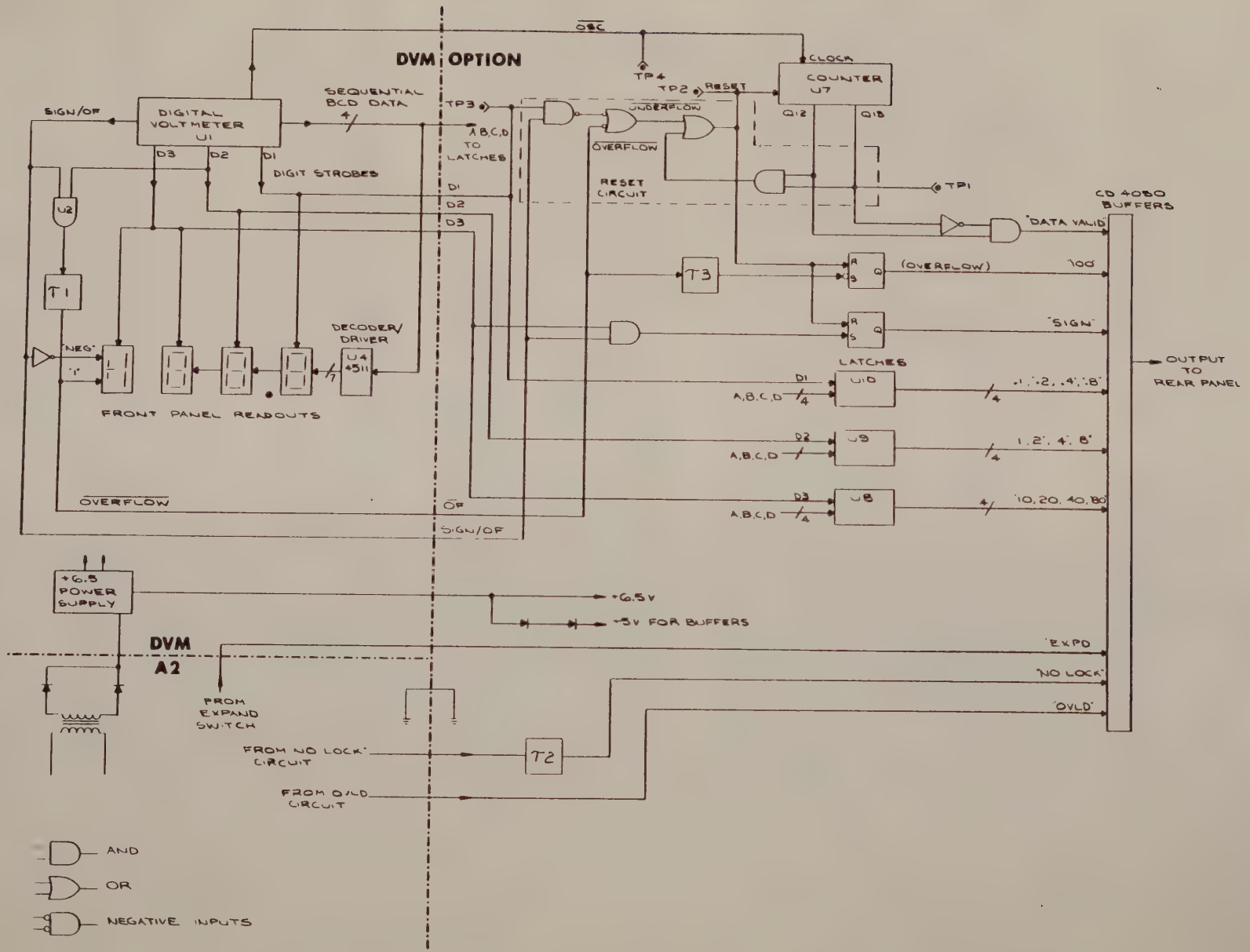


FIGURE A4.1
SIMPLIFIED SCHEMATIC
BCD OPTION

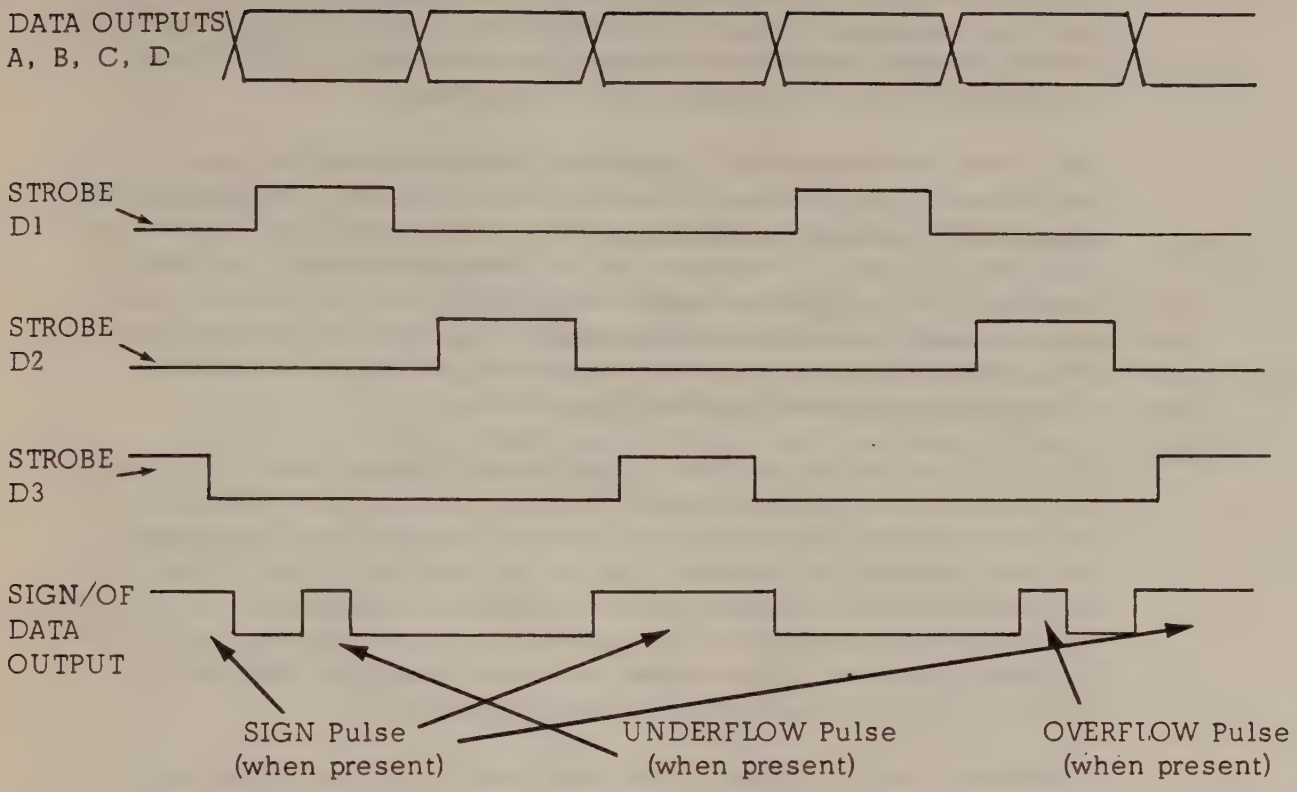


FIGURE A4.2 DVM TIMING

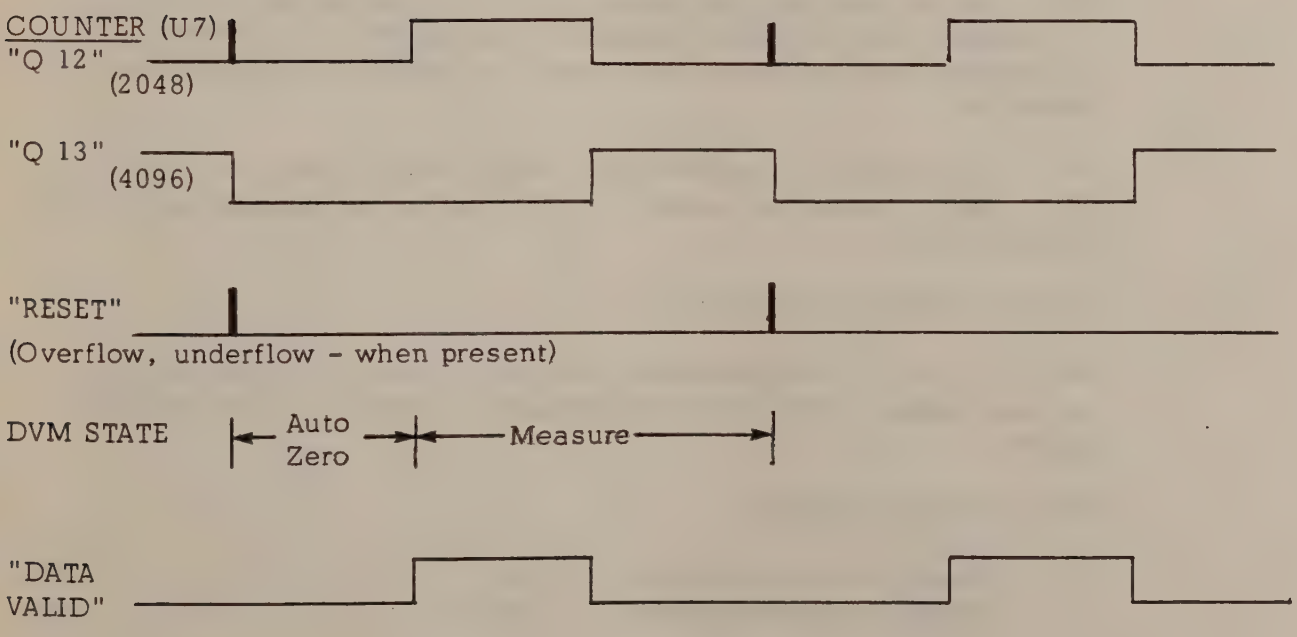


FIGURE A4.3 BCD OPTION TIMING

To create the Data Valid output, and to reset the overflow ("100") and SIGN latches, a counter (U7) is present. This counter counts the DVM oscillator and divides that frequency by exactly 6144. This corresponds to the conversion rate of the DVM.

The reset circuit shown in Figure A4.1 performs two functions. First, the output of the counter Q12 and Q13 are decoded by an AND gate to reset the counter when it reaches 6144. (Q12 = 2048 and Q13 = 4096) This sets the proper frequency for the Data Valid signal. Second, the overflow and underflow signals are decoded from the SIGN/OF signal and are used to synchronize the counter. (Underflow occurs during D1). The underflow, overflow, and counter output are combined in OR gates and are used to reset the counter.

The "100" output or overflow is latched as follows: when the counter is synchronized, the reset pulse from the reset circuit occurs very nearly in time to when the overflow pulse occurs. This short reset pulse is applied to the reset input of the overflow latch. (This latch is made from single gates) The overflow pulse, however, is stretched out by the time constant T3 and applied to the set input of the latch. T3 guarantees that the set pulse will last longer than the reset pulse, so if a set pulse is present, the latch will be set.

The sign output is similar to the overflow. The latch is reset once for each conversion by the counter, and is set by the SIGN signal from the DVM. Since the SIGN signal occurs during each D3 interval, there is no need to stretch it.

The signals from the lock-in, OVERLOAD, NO LOCK, and EXPAND are processed by level shifting networks and sent to the output buffers. In addition, the NO LOCK signal has a pulse stretcher T2 which eliminates the blinking which is sometimes seen on the front panel indicator.

All output signals are buffered by CD4050 CMOS buffers U4, U5 and U11. This provides the correct 5 volt output levels and adequate current to drive TTL loads.

A4.1.4 TROUBLESHOOTING OPTION 05

The user should understand the operation of this Option before trying to troubleshoot. Refer to the operating instructions and the description above.

DATA OUTPUTS MISSING

Check Power to Option (+6.5 volts).
Check for D1 signal (TP3), D2 and D3.

Check for A, B, C, D signals at input to latches. Trigger the scope on TP3 to observe these signals.
Individual outputs may disappear because of shorts or faulty latch IC's.

DATA VALID SIGNAL MISSING OR WRONG

Look for a square oscillator signal at TP4 at approximately 20 kHz.
Check Q13 (TP 1) for an asymmetrical output (see Figure A1.1). If this is symmetrical or absent, check the reset circuit.
The reset signal at TP2 should normally be 0 volts. The positive pulses are small and may not be seen with some scopes. If this signal remains true, work backwards through the circuit to find the cause.

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			CAPACITORS			
C1	11-B3	D5	.068μF, 200V, 10%, Mylar	811553005	22	W210B1C-683K
C2	11-B3	D5	0.1μF, 200V, 1%, P.C.	811540028	22	W625131C104F
C3	11-C3	C5	15μF, 20V, 10%, Tant	811504020	48	196D-156X9020KA1
C5	11-E3	C3	47μF, 20V, 10%, Tant	811504021	48	196D-476X9020LA3
C6	11-E3	C5	.01μF, 500V, 20%, Cer	811570019	48	5GAS-S10
C7	11-E4	C4	.0015μF, 100V, 10%, Mylar	811551009	28	6-1-F10AA152
C8	11-E7	B4	.22μF, 35V, 10%, Tant	811501187	48	150D224X9035A2
C9	11-E4	C4	.01μF, 500V, 20%, Cer	811570019	48	5GAS-S10
			DIODES			
CR3	11-D2	D3	IN4148	818100003		IN4148
CR4	11-D2	D3	IN4148	818100003		IN4148
CR5	11-A7	C3	IN4148	818100003		IN4148
J1	11-E8	B2	Connector, 14 pin Dip Socket	812129113	101	CA-14S-10SD
J2	11-E7	B6	Connector, 14 pin Dip Socket	812129113	101	CA-14S-10SD
			RESISTORS			
			All resistors unless otherwise designated are 1/4W, 5%, Comp * 1/8W, 1%, Metflm ** 1/8W, 0.1%, Metflm ***1/10W, 1%, Temp Stable, Metflm			
R1	11-B3	C4	2.2K, 1/4W, 5%	817007222		RC07
R2	11-B2	C4	13.3K, 1/8W, 1%	818212133		RN60D
R3	11-C2	C4	2K (POT)	817801114	29	66XR2K
R4	11-C2	D5	9.09K, 1/8W, 1%	817211909		RN60D
R5	11-C2	D5	1.00K, 1/8W, 1%	817211100		RN60D
R6	11-C2	C4	5.11K, 1/8W, 1%	817211511		RN60D
R7	11-D2	C4	2.7K, 1/4W, 5%	817007272		RC07
R8	11-D2	D3	220 ohm, 1/2W, 5%	817020221		RC20
R9	11-E2	C4	2.2K, 1/4W, 5%	817007222		RC07
R10	11-D3	C2	220 ohm, 1/4W, 5%	817007221		RC07

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			RESISTORS (continued)			
R11	11-D3	D3	1.8 ohm, 1/2W, 5%	817000022	3	EB18G5
R12	11-C3	D5	3.3K, 1/4W, 5%	817007332		RC07
R13	11-D3	D5	6.8M, 1/4W, 5%	817007685		RC07
R14	11-D3	C4	50K (POT)	817804503	7	3386W-1-503
R15	11-B6	B5	22K, 1/4W, 5%	817007223		RC07
R16	11-B6	B5	22K, 1/4W, 5%	817007223		RC07
R17	11-B6	B5	22K, 1/4W, 5%	817007223		RC07
R18	11-E7	B4	1.5M, 1/4W, 5%	817007155		RC07
R19	11-E2	C4	2.2K, 1/4W, 5%	817007222		RC07
R20	11-F2	C4	2.7K, 1/4W, 5%	817007272		RC07
R21	11-F2	D5	330 ohm, 1W, 5%	817032331		RC32
R22	11-E3	C4	3.3K, 1/4W, 5%	817007332		RC07
R23	11-C7	C3	180 ohm, 1/4W, 5%	817007181		RC07
R24	11-C7	C3	180 ohm, 1/4W, 5%	817007181		RC07
R25	11-C7	C3	180 ohm, 1/4W, 5%	817007181		RC07
R26	11-D7	B3	180 ohm, 1/4W, 5%	817007181		RC07
R27	11-D7	C3	180 ohm, 1/4W, 5%	817007181		RC07
R28	11-D7	B3	180 ohm, 1/4W, 5%	817007181		RC07
R29	11-D7	C3	180 ohm, 1/4W, 5%	817007181		RC07
R30	11-E7	C3	180 ohm, 1/4W, 5%	817007181		RC07
R31	11-E7	C2	90.9 ohm, *	817219909		RN60D
R32	11-A7	C3	180 ohm, 1/4W, 5%	817007181		RC07
R33	11-D5	C4	3.3K	817007332		RC07
R34	11-C6	D4	220 ohm	817007221		RC07
R35	11-E6	B5	10 ohm	817007100		RC07
R36	11-E3	D4	1.2K	817007122		RC07
R37	11-E4	C4	1M, 1/4W, 5%	817007105		RC07
			TRANSISTORS			
Q1	11-B3	C5	FET - E204	818700041		E204
Q2	11-D2	D3	2N3904	818203904		2N3904
Q3	11-D3	C2	2N4918	818204918		2N4918
Q4	11-F2	C4	2N3906	818203906		2N3906
Q5	11-B7	B3	MPS-A14	818700013		MPS-A14

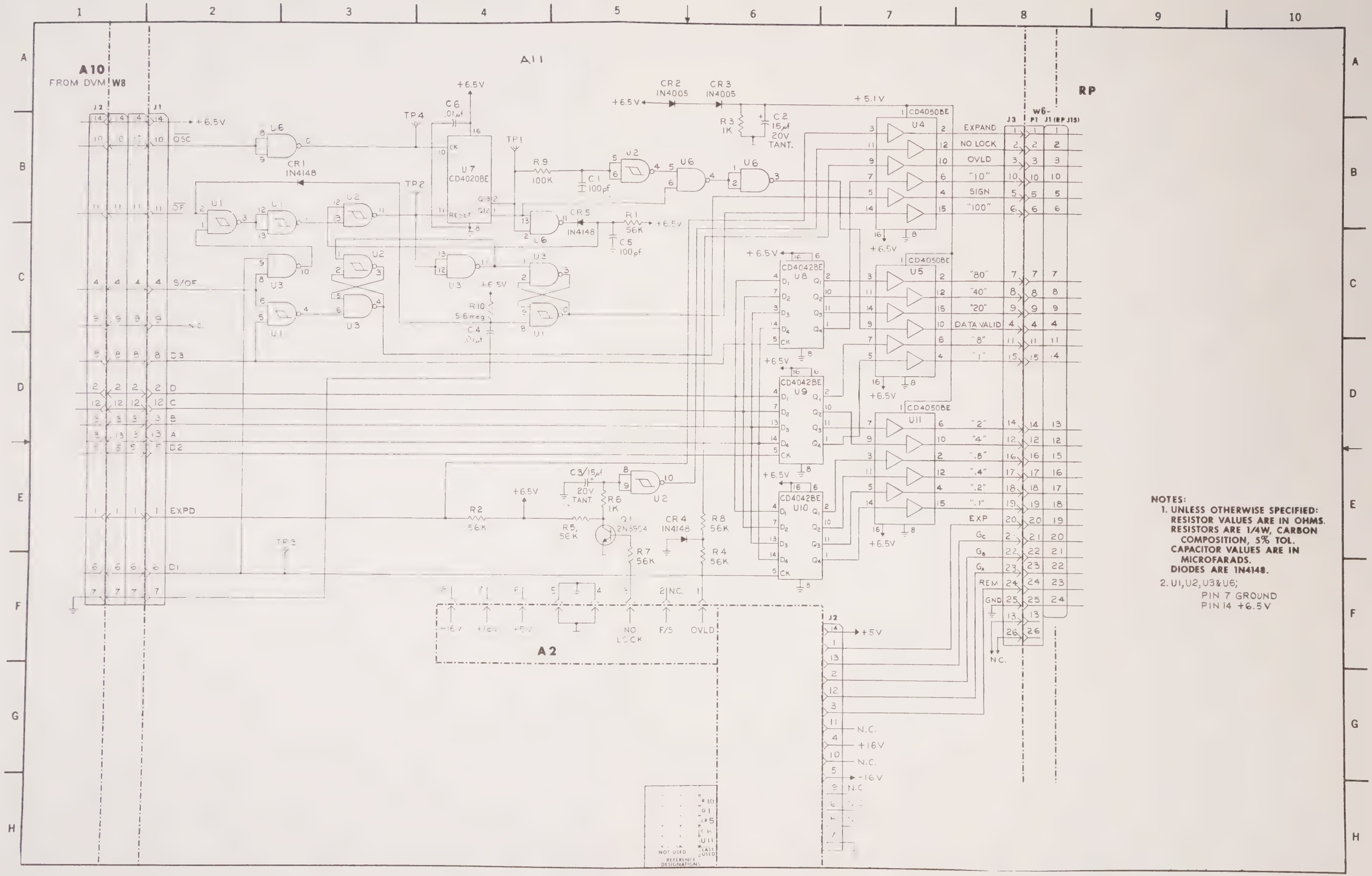
REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			TRANSISTORS (continued)			
Q6	11-B7	C3	MPS-A14	818700031		MPS-A14
Q7	11-B7	B3	MPS-A14	818700031		MPS-A14
Q8	11-D7	C3	2N3904	818203904		2N3904
Q9	11-E7	C2	2N3904	818203904		2N3904
Q10	11-C7	D4	2N2905	818202905		2N2905
Q11	11-E6	B5	2N3906	818203906		2N3906
			INTEGRATED CIRCUITS			
U1	11B, D4	C5	LD131J	816400066	100	LD131CJ
U2	Sh. 11	C4	CD4093BE	816374093		CD4093BE
U3	11-B3	C3	LM3999Z	816400065	36	LM3999Z
U4	11-D7	C4	CD4511BE	816374511		CD4511

FRONT PANEL ASSEMBLY D42042G1 397EO

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
A12	11-E8		Asm Digital Display	B22646G1	31	B22646G1
DS1	11-D10	A2	Seg Display	812975006	83	5082-7616
DS2	11-D9	A2	7 Seg Display	812975005	83	5082-7613
DS3	11-D9	A3	7 Seg Display	812975005	83	5082-7613
DS4	11-D8	A3	7 Seg Display	812975005	83	5082-7613
J1	11-E8	A2	14 Pin Dip Socket	812129113	101	CA-14S-10SD
J2	11-D10	A2	14 Pin Dip Socket	812129113	101	CA-14S-10SD
J3	11-D9	A2	14 Pin Dip Socket	812129113	101	CA-14S-10SD
J4	11-D9	A3	14 Pin Dip Socket	812129113	101	CA-14S-10SD
J5	11-D8	A3	14 Pin Dip Socket	812129113	101	CA-14S-10SD
DS1	12-D4		Diode, Light Emit GRN	818149007	78	521-9203
DS2	8-F7		Diode, Light Emit RED	818149006	78	521-9165
DS3	12-F4		Diode, Light Emit RED	818149006	78	521-9165
DS4	10-E7		Diode, Light Emit YEL	818149013	102	MV5353
DS5	12-D5		Meter Lamp, G.E. 346, 18V	813900026	28	346
DS6	12-D5		Meter Lamp, G.E. 346, 18V	813900026	28	346

REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			CAPACITORS			
C1	B5	E3	100pF, 10%, Cer	811572011	48	10TS-T10
C2	A6	D4	15µF, 20V, 10%, Ta	811504020	48	196D-156X9020KA1
C3	E5	D5	15µF, 20V, 10%, Ta	811504020	48	196D-156X9020KA1
C4	D4	E3	.01µF, 500V, 20%, Cer	811570019	48	5GAS-S10
C5	C5	E4	100pf, 10%, Cer	811572011	48	10TS-T10
C6	B4	E4	.01µF, 500V, 20%, Cer	811570019	48	5GAS-S10
			DIODES			
CR1	B3	E3	IN4148	818100003		IN4148
CR2	A5	E4	IN4005	818100007		IN4005
CR3	A6	E4	IN4005	818100007		IN4005
CR4	E5	E5	IN4148	818100003		IN4148
CR5	C5	F3	IN4148	818100003		IN4148
J1	B2	D3	Connector 14 Pin Dip	812129113	101	CA-14S-10SD
J2	F7	E3	Connector 14 Pin Dip	812129113	101	CA-14S-10SD
J3	B8	D6	Connector 26 pin Str. Con.	812127022	103	609-2622M
Q1	E5	D4	Transistor 2N3904	818203904		2 N3904
			RESISTORS			
			All resistors unless otherwise designated are 1/4W, 5%, Comp * 1/8W, 1%, Metflm ** 1/8W, 0.1%, Metflm ***1/10W, 1%, Temp Stable, Metflm			
R1	C5	E4	56K	817007563		RC07
R2	E4	E4	56K	817007563		RC07
R3	A6	E4	1K	817007102		RC07
R4	F6	E4	56K	817007563		RC07
R5	E5	E4	56K	817007563		RC07

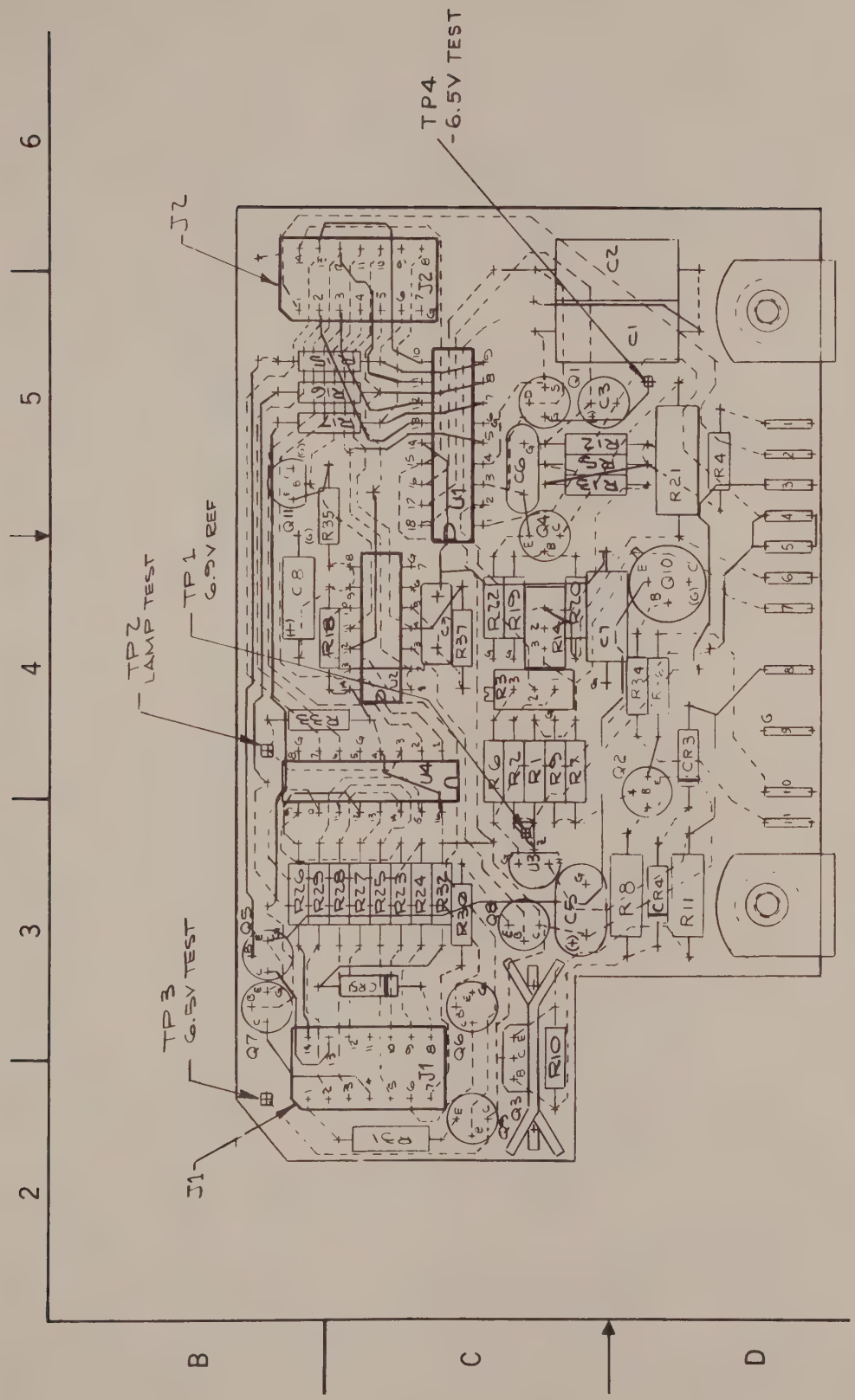
REFERENCE DESIGNATION	LOCATION SCH	LOCATION ASM	DESCRIPTION	ITHACO PART NUMBER	MANUFACTURER CODE	MANUFACTURER PART NUMBER
			RESISTORS (continued)			
R6	E5	E5	1K	817007102		RC07
R7	F5	E5	56K	817007562		RC07
R8	E6	E5	56K	817007562		RC07
R9	B4	E3	100K	817007104		RC07
R10	C4	E3	5.6M	817007565		RC07
			INTEGRATED CIRCUITS			
U1	C3	E3	Quad 2IN NAND Sch Trig	816374093		CD4093BE
U2	C3	D4	Quad 2IN NAND Sch Trig	816374093		CD4093BE
U3	C5	D4	Quad 2 INPUT NAND Gate	816374011		CD4011BE
U4	B7	D5	Hex Buffer/Con	816374050		CD4050BE
U5	C7	D5	Hex Buffer/Con	816374050		CD4050BE
U6	B2, 6	E3	Quad 2 INPUT NAND Gate	816374011		CD4011BE
U7	B4	E4	14 Stg R-C Bin Ctr/Drv	816374020		CD4020BE
U8	C6	E4	Quad Clocked D Latch	816374042		CD4042BE
U9	D6	E5	Quad Clocked D Latch	816374042		CD4042BE
U10	C7	E5	Quad Clocked D Latch	816374042		CD4042BE
U11	E7	E5	Hex Buffer/Con	816374050		CD4050BE



NOTES:
1. UNLESS OTHERWISE SPECIFIED: RESISTOR VALUES ARE IN OHMS. RESISTORS ARE 1/4W, CARBON COMPOSITION, 5% TOL. CAPACITOR VALUES ARE IN MICROFARADS. DIODES ARE 1N4148.
2. U1, U2, U3 & U6; PIN 7 GROUND PIN 14 +6.5V

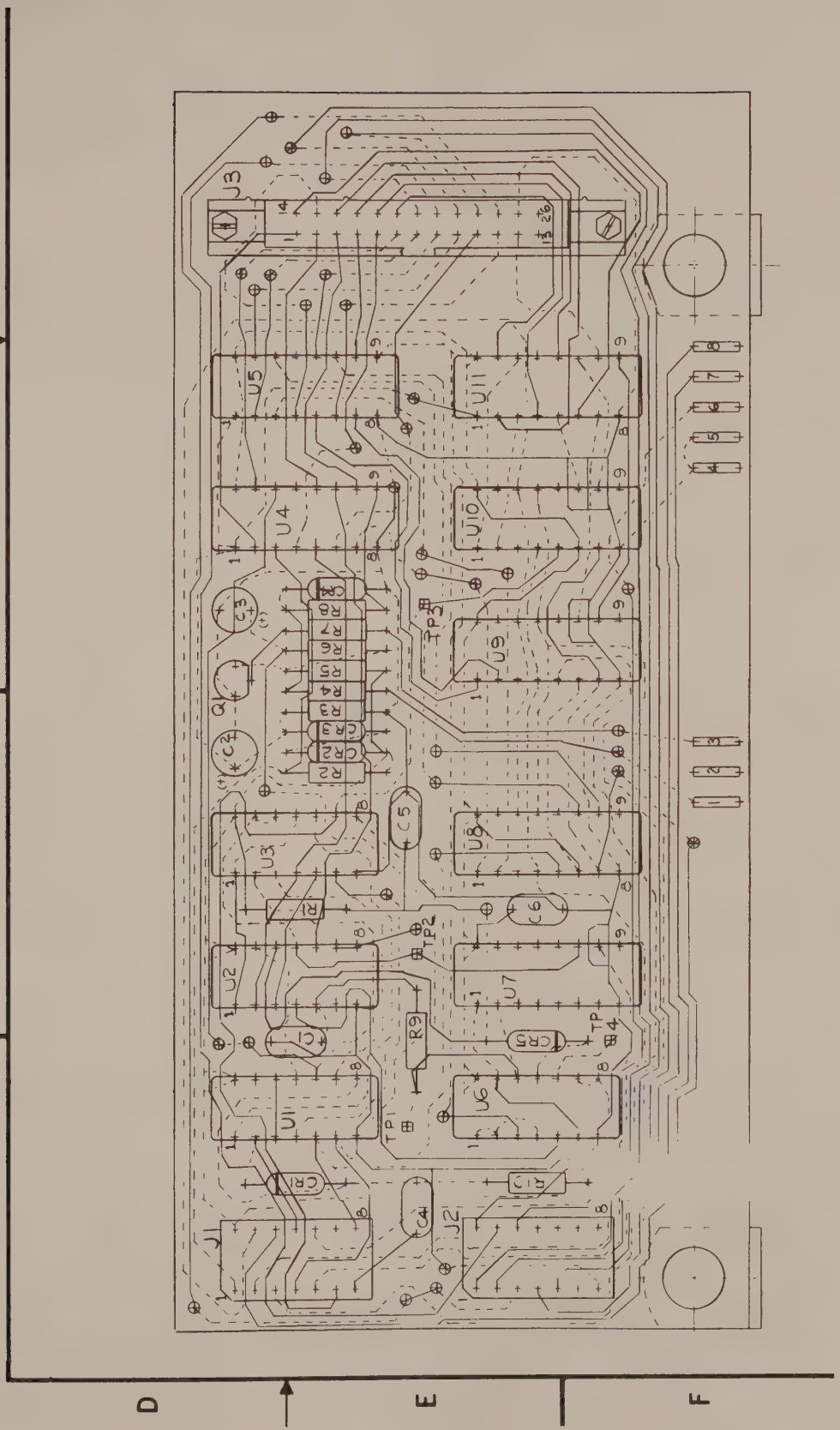
ITHACO DWG D42049, REV B, 3/79

FIGURE A1 SCHEMATIC – BCD OPTION 05



ITHACO DWG C32271, SH 1, REV B, 9/78

FIGURE A2 ASSEMBLY – A10 DVM CARD



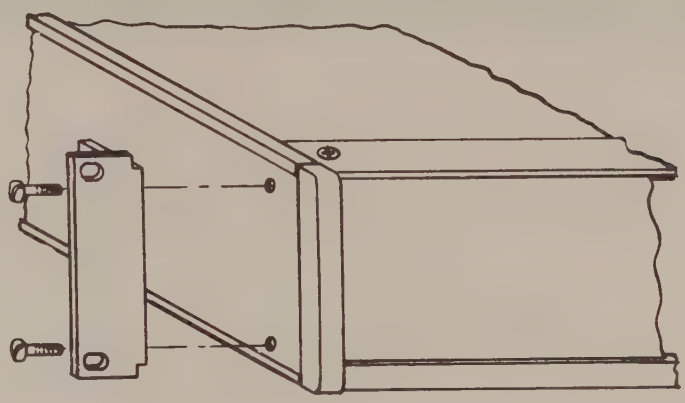
ITHACO DWG D42058, REV A, 7/78

FIGURE A3 ASSEMBLY – BCD OPTION 05

INSTALLATION INSTRUCTIONS FOR ITHACO RACK MOUNTING KITS RM–1 AND RM–2

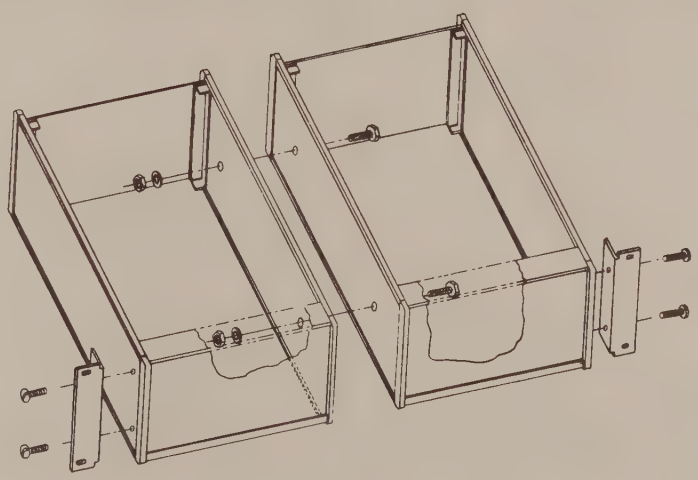
RM–1 FOR 17'' WIDE FULL RACK CHASSIS:

Remove the two screws at the front of each side cover. Place mounting ears of the RM–1 kit in place and secure using the screws previously removed.



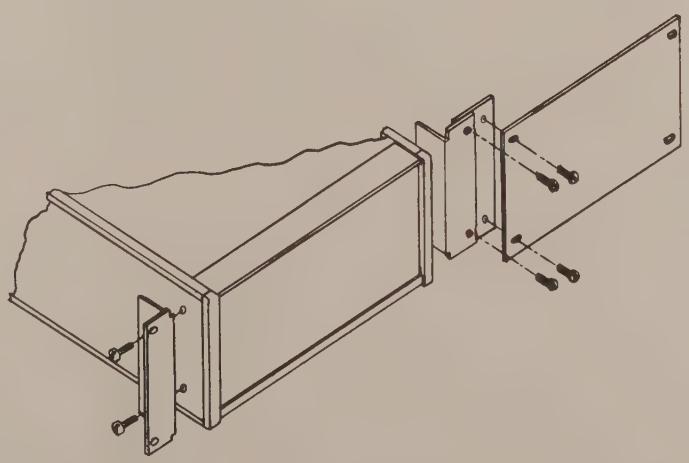
RM–1 FOR TWO 8½'' WIDE HALF RACK CHASSIS:

Remove opposite side covers from each unit. Remove top covers from each unit, secure the units together side by side, using nuts and bolts supplied. Replace the top covers, attach mounting ears in the same manner as a full rack unit.



RM–2 FOR A 8½'' WIDE HALF RACK UNIT

Remove the two screws at the front of each side cover. Place mounting ears in place and secure, using the screws previously removed. Attach extender plate to mounting ear on the desired side of the unit, secure using the threaded nut bar and hardware supplied.



RECOMMENDED HANDLING PROCEDURES FOR STATIC SENSITIVE DEVICES

ITHACO
735 W. Clinton St. Box 6437 Ithaca, New York 14851 6437 Phone 607 272 7640 TWX 510 255 9307

GENERAL

Static Sensitive Devices (Insulated Gate), due to their extremely high input resistance, are subject to potential damage by the accumulation of excess static charge. To avoid possible damage to the devices during handling, testing, or actual operation, these procedures should be followed:

NOTE: Dry weather (relative humidity less than 30%) tends to multiply the accumulation of static charges on any surface. In a low humidity environment, the handling precautions take on added importance and should be adhered to without exceptions.

Various electrical and electronic parts which have been determined to be sensitive to electrostatic discharge include: microelectronic and semiconductor devices, thick and thin film resistors, chips and hybrid devices, and piezoelectric crystals. Additionally, all subassemblies, assemblies and equipment containing these parts not having adequate protective circuitry are also electrostatic discharge sensitive (ESDS).

PROCEDURE

A. The leads of the devices should be in contact with a conductive material except when being tested or in actual operation, to avoid the build–up of static charge.
   1. The conductive material may be a conductive foam, metal foil, conductive rings or other suitable material.

B. Devices should not be inserted in non–conductive containers such as conventional styrofoam, plastic bubble paper, or trays.

C. When devices are removed from their conductive material, the hand being used should be grounded by a metal wrist strap which has a 1 megohm resistor in series with the wire between the strap and ground.

D. All soldering iron tips, test equipment, tools and fixtures must be grounded. Table tops and work surfaces should be conductive and grounded.

E. All grounds must be common and should be made as close together as possible.

F. Devices should not be inserted into or removed from circuits with the power on.

G. Signals should not be applied to the inputs while the device power supply is off.

Condensed from ITHACO MOP 30.110, May, 1983

WARRANTY

LOCK-IN AMPLIFIERS AND ACCESSORIES

ITHACO, Inc. warrants each instrument to be free of defects in material and workmanship for a period of two years, unless otherwise specified, after shipment to the original purchaser; batteries and light beam choppers are specifically excluded. Liability under this warranty is limited to repairing or adjusting any instrument returned to the factory for that purpose. The warranty of this instrument is void if the instrument has been modified other than in accordance with written instructions from ITHACO, or if defect or failure is judged by ITHACO to be caused by abnormal conditions of operation, storage or transportation.

This warranty is subject to verification by ITHACO, that a defect or failure exists, and to compliance by the original purchaser with the following instructions:

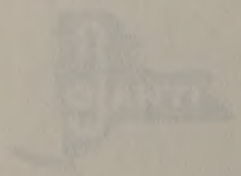
1. Before returning the instrument, notify ITHACO with full details of the problem; including the model number and serial number of the instrument involved.

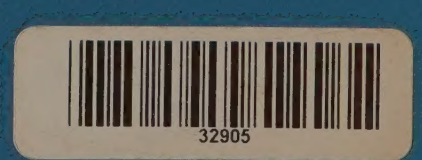
2. After receiving the above information, ITHACO will give you shipping instructions or service instructions. After receipt of the shipping instructions, ship the instrument to ITHACO. Full liability for damage during shipment is borne by the purchaser. It is recommended that instruments shipped to us be fully insured and packed surrounded by at least 2 inches of shock-absorbing material.

ITHACO reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

This warranty is expressly in lieu of all other obligations or liabilities on the part of ITHACO, and ITHACO neither assumes, nor authorizes any other person to assume for it, any liability in connection with the sale of ITHACO instruments.

ITHACO INC.
735 West Clinton Street
P O Box 6437
Ithaca, New York 14851-6437
Phone 607-272-7640

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